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SOURCE BOOK ON THE APPLICATION OF RESEARCH TO GROUND TRAINING IN AVIATION

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SOURCE BOOK ON THE APPLICATION OF RESEARCH TO GROUND TRAINING IN AVIATION

(Psychological Studies of Training Techniques)

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Those sources concerned specifically with aviation training usually have pointed their research at training in the air rather than on the ground. There is an extensive literature upon such problems. Relatively few investigations have been performed upon the problems of instruction of the aviator on the ground.

Listed below are major sources which have been reviewed with the purpose of assembling the contribution of research to ground training in aviation, whereas the number of individual studies reported from these various sources runs into the thousands, very few indeed contribute to procedures for or validation of ground aviation training.

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## C. RESPONSIBILITY

The survey of the literature and preparation of this report were performed by Dr. Douglas H. Fryer, associate Director, SDC Project 20-E-6, of the firm of Richardson, Bellows, Henry and Co., Inc.

# PART II. RESEARCH SUMMARIES

## A. STUDY SKILLS

Little attention has been paid by the Armed Forces to the individual trainee's ability to study, and particularly his ability to read. Those of less than the "fourth grade school level" (about 8% of inductees) were sent to a Special Training Unit by the Army during the last war. There were few such in the Navy and Marines. But once an inductee was classified in the Armed Forces as literate, the existence of study skills adequate for any training was assumed. Not many leaders in military training have considered very seriously the obvious fact that failures at all levels in civilian education — at elementary school, secondary school, and college -- often are due to inability to read effectively.

### 1. Conclusions from Civilian Research

Since little has been done to understand this problem in military instruction, a brief review will be given here of conclusions from civilian research.

#### a. Reading: A Skill

Reading is a basic skill in all accomplishment. As the training activity becomes more complicated, the reading requirement becomes more complex. More and more symbolic comprehension, such as reading charts, tables, maps, and code is required of the student. Greater speed in the reading is required, which means that more rapid comprehension is required. The whole reading act is stepped up in skill requirements as the individual progresses in any training program. His failure at any point may be due not so much to the obvious skills of the program -- those on which he is graded -- as to lack of the skills of comprehension of symbolic reading material. Such a conception of training emphatically applies to the student of aviation throughout his training.

#### b. Reading Conditions

The reading act has been under investigation for at least three decades, and some very important guides have been established for the improvement of reading. First, prior to examination for good reading, there should be the following checks:

Typography of the reading material in book or on chart should be checked against known standards.

Illumination for the reading should be checked against known standards for reading efficiency, comfort, and fatigue.

Visual acuity of the individual should be checked for distances at which the visual work is performed.

These factors may be quite unimportant in reading efficiency and yet they may. Proper correction of them should be made to achieve the best conditions for the reading.

c. Reading Examination

With the foregoing conditions optimum, the individual then should be examined as to his reading proficiency. Prognostic tests are available for measurement at various developmental levels. They measure largely two factors, comprehension level and speed of reading.

Such testing must be accomplished at the level of the work or training under consideration, and norms are necessary for that level and for the area of study in order to interpret the test results. For example, it is all right to say that a college freshman who reads 200 words of English composition a minute is deficient in reading speed. The average is about 250 words a minute. But it is wrong to say that he is deficient in reading speed if he reads at this rate in chemistry where the average is much lower. So with all work, the required comprehension and reading rate specific to the task must be determined for the individual to progress in his training or accomplish his assignment.

d. Training Rules

Signposts for training in reading skills have been established in civilian institutions, and among these the more important for application at the level of training in the Naval Air Training Command are:

1) Determine the purpose of the reading, what is to be sought, what is to be emphasized, what is to be remembered.

2) Scan what is to be read, using table of contents, index, topics, topic sentences, etc. Do this wherever possible to gain the information desired. It should be done to determine the purpose of the reading wherever this is not clear, or before intensive study takes place.

3) Carry on productive thinking during the reading, sorting out relevant material, and organizing it into the pattern of study. Where mind-wandering, due to fatigue or distraction, is too great to be overcome by this method, do not attempt to study — do something useful.

4) Carry on special vocabulary study to improve knowledge of word symbols, mathematical study to improve knowledge of figure symbols, any other tool study to improve knowledge of all basic tools necessary to comprehension.

5) Establish speed goals for the reading or study and increase them with personal incentives, e.g., if I complete this in an hour, I will take a recess.

6) Introduce rest periods into the study time when units of study are completed to gain relaxation from tension.

Two principles resulting from research are particularly applicable to improvement in reading:

1) Time spent in reading improves reading comprehension.

2) Motivation to read faster causes faster reading.

Many industrial executives who have to read a great many papers have improved their reading by the use of these principles. They are equally applicable to Naval officer training.

2. Navy Research

In the interest of developing a device for the Navy for improving level of comprehension, an experiment has been carried on at the Institute of Applied Psychology, Tufts College (25), to test the relationship between comprehension and eye-movements. The reading materials and comprehension checks were taken from standardized reading achievement tests and eye-movements while reading was recorded by means of the electroculogram technique. The experiment has been conducted at the college level of study and only a preliminary report of the research is as yet available.

Comprehension scores were studied in relation to total time taken to read the experimental selection, total number of eye-movements made while reading the selection, number of saccadic movements made in a left-right direction and in a right-left direction along the line of print. Correlations between total count and number of left-right saccadic movements with comprehension score were not found to be significant. However, number of regressive saccades and total time were found to predict the comprehension score. A multiple correlation involving number of regressive (right-left) saccadic movements and

total reading time predicted the comprehension score .433, which is significant at the 1% level.

Reading time and comprehension score predicted the number of regressive saccades .46; and the comprehension score and regressive saccades predicted reading time .45 (both significant at the 1% level), indicating that regressive eye-movements are involved in both rate of reading and comprehension. Thus the future goal of this research project is to determine if a measure of ocular efficiency is valuable to predict reading level in the Navy.

## B. ESTABLISHING THE CURRICULUM

The curriculum or content of ground instruction in the Naval Air Training Command has been developed from what has been considered by experts as necessary for the aviator to know. It never has been checked with training needs by an analysis of operational billets.

### 1. Determining Needs for Training

#### a. Conference Results (NATC)

A conference of Naval officers with representatives from the Fleet has been held yearly in the Naval Air Training Command for discussion of training needs. While the "ideas of the conference" have served as a check upon current training procedures, the usual conclusion has been that nothing was added to what was known before in the Command about the training of Naval aviators.

#### b. Questionnaire Results (NATC)

A questionnaire survey was made of Fleet needs for training by the Naval Air Training Command (1946) which was of dubious value because the questions were improperly prepared for expression of opinion or analysis of results, and all that was gained were vague impressions. Properly prepared and effective in sampling, such an opinion survey should contribute information of needs for training.

#### c. Interview Results in Determining Operational Deficiencies (Army Air Forces)

Operational deficiencies in training have been determined in the Army Air Forces by the interview method (18). Professional interviewers interviewed group and squadron commanders and operation officers for complaints indicative of needed training. The complaints found most frequently were:

1) Inadequate knowledge of engines and other mechanical equipment in planes.

2) Lack of understanding of basic theory of operating equipment as contrasted with knowledge of rules governing use of equipment.

Such an opinion survey has definite value in determining specific emphases needed in training. Two serious lacks were segregated in the navigation training program of the Army Air Forces in similar manner:

3) Faulty understanding of the principles of latitude computation.

4) Clerical facility in simple arithmetic involved in navigation computation.

## 2. Job Analysis for Training Purposes

Periodically during the last war and since, it has been recommended to various echelons of authority that an analysis be made of the job of the Naval aviator to find out what he should be trained to do. Such a billet analysis for training purposes has never been performed. Instead, representatives of the Fleet have been invited into conference to criticize training procedure or syllabi; or representatives of the Training Command have been sent to the Fleet as observers, with the result that specific disparities between training and operations have been noted, but at no time has it been possible to establish a curriculum on previously determined operational requirements.

Billet analysis is performed for various purposes, such as preparing specifications for requisitioning of personnel and the writing of description for billet evaluation, orienting personnel on the job, and the placing of responsibility. The analysis of jobs for training purposes aims to indicate the skills and degree of skills necessary to perform the tasks of the billet assignment, and for this reason it is the most difficult form of analysis. Such an analysis should have as its primary purpose a sifting of qualities of performance to determine those that distinguish success from failure on the job. These are the ones which training must emphasize.

The job-analysis procedures of the Aviation Psychology Program in the Army Air Forces were more analytical and less descriptive. An attempt was made to translate the requirements for success as an aviator from statements of the actual operation performed into statements of measurable abilities, aptitudes, and personality traits believed to underlie this behavior (18, 272-276). Emphasis was placed on critical requirements, those which were demonstrated to have made the difference between success and failure in carrying out an important part of the job in a significant number of instances. Procedures were developed for making an analysis of causes of good and bad performance. First, they consisted in obtaining first-hand reports of satisfactory and unsatisfactory execution of assigned tasks from individuals performing the tasks, their subordinates, their co-participants, and their superiors. Later check-lists were substituted because of the incompleteness of such reports. The analysis of data was in relation to the frequency of the reported difficulty on the check-list; and the check-list was recommended for use in reporting student progress in training.

## C. EVALUATING PROFICIENCY

Experience with achievement testing throughout the Armed Forces — in the Army, Navy, and Air Force — has led to the conclusion that, through the use of achievement tests, the rating and grading of students in training has been improved. This conclusion is supported by three types of evidence in the Armed Forces: a) an increase in intercorrelation between various grades following the introduction of standardized achievement examinations in training courses; b) the increased prediction of training school success from classification tests when achievement examinations are used as criteria for the grading; and c) a greater likelihood that students from different schools will have similar training. A like conclusion is warranted from achievement testing in civilian educational institutions.

### 1. Achievement Testing Programs

The Navy achievement testing program was closely associated with the effort to standardize curriculum and instruction and to establish a better base for comparing school-trained personnel. The introduction of the final achievement examination and the comprehensive practical examination into the Tactical Radar School brought about a better definition of the criterion of success (50, 315-330). This is evident in the improved intercorrelations among the grades making up final grade. Table 1 shows the intercorrelations of grades before and after the introduction of standardized achievement examinations at the Tactical Radar School. The 5th Class is used as an example of results obtained before introduction of standardized achievement tests; the 9th Class is used as representative of results obtained afterward.

TABLE 1

Intercorrelation of Grades at the Tactical Radar School
Before and After Introduction of Standardized Achievement Tests

| Grade | Class | Grade: Achievement Examination | Theory Grade | Practical Grade |
|---|---|---|---|---|
| Achievement Examination | 5th Class | --- | .59 | .11 |
| | 9th Class | --- | .78 | .66 |
| Theory Grade | 5th Class | .59 | --- | .13 |
| | 9th Class | .78 | --- | .69 |
| Practical Grade | 5th Class | .11 | .13 | --- |
| | 9th Class | .66 | .69 | --- |
| Final Grade | 5th Class | .80 | .89 | .31 |
| | 9th Class | .91 | .93 | .84 |

The 9th Class intercorrelations are considerably higher than those for the 5th Class; this is evidently due to replacing a rating of performance with a comprehensive practical examination.

The Aviation Psychology Program of the Army Air Forces had as one of its functions the evaluation of existing proficiency measures used in the training of air crew specialties, along with the development of proficiency examinations for the air crew specialty training units (18, 115-138). Most of the work in this program, however, was concerned with flying proficiency (33, 73-109). It was found very early that there were practically no eliminations in pilot training schools in the Army Air Forces for reasons other than flying proficiency, although students were sometimes held over because of deficiencies in academic ground training. Only in Navigation, of the various air crew specialties training programs in the Army Air Forces, was substantial weight given to ground school grades in determining whether a trainee should be eliminated or graduated.

2. Reliability of Grading

The reliability of grades is often determined by correlations between elementary and advanced courses or between examinations in the same course. Reliabilities are reported of .93 to .97 for grades of odd-numbered and even-numbered weeks in six schools of the Great Lakes Service Station for Electrician Mate, Fire Control, Gunner's Mate, Torpedoman, Quartermaster, and Signalman (53).

Reliability correlation coefficients comparing grades for odd- and even-numbered weeks of 308 graduates in Navigation Training School in the Army Air Forces are reported (18, 122) as follows:

| | |
|---|---|
| Reliability of lecture grades, based on daily classroom performance | .82 |
| Reliability of examination grades, based on weekly examinations | .90 |

When the same instructors assign grades for both odd and even weeks, or when the instructors know the grades of their students in previous weeks, correlation between grades on odd and even weeks tend to be spuriously high.

It was considered in the Aviation Psychology Program of the Army Air Forces that the Navigation Ground School grading system was much the most reliable of those of the air crew specialties ground schools (18, 122). Ground school grades, based on performance tests and objective examinations in the separate courses, both in Pre-Flight and Flight Engineering Schools, correlated only .20 to .50. The final Pre-Flight Engineering School grade and the final school grade at the Flight Engineering School, with very low student elimination for 747 men, correlated .60, showing a fair degree of reliability in final ground school grading.

### 3. Special Proficiency Examinations

#### a. Navigation

The Army Air Forces developed a series of ground measures consisting of a navigation proficiency test, a motion-picture test, a photographic test of pilotage, and an instrument-phase check, to be used in testing the proficiency of navigators (18, 125-126; 36). The navigation proficiency test, which consisted of 120 multiple-choice items in 8 areas of navigation training and was designed to emphasize those aspects of navigation skill most needed in actual combat, was administered to 261 trainees about to graduate from navigation training and 366 returnee combat navigators. A comparison of the results for the two groups showed the test to be primarily a measure of theoretical classroom knowledge. A revision of this test was made to overcome this deficiency. Nine sub-tests were included and the attempt was made to emphasize technique, procedure, practical applications, and judgment in navigation. The nine sub-tests intercorrelated .30 or lower. The correlation of student scores on this test with ground and flight grades was below .20 for a sample of 74 graduating cadets. It seemed impossible to develop an information test of navigation that would predict operational proficiency, and there may be a correlary, that amount of navigation information is not the important factor in navigation skill.

The test of pilotage required the location of position in the air by the identification of ground features on a map consisting of aerial pictures and maps on which the photographs must be identified. A sequence of photographs simulated the flight of a plane along a given course with the navigator looking at the ground at intervals. Time limits were included for viewing each photograph according to possible air times for viewing the terrain, and the testee was not allowed to look back at photographs previously viewed. This test was never evaluated, but it appeared to the navigators who examined it that it simulated the task of pilotage fairly exactly.

The motion-picture test, which also was never validated, consisted of a continuous film taken at an altitude of 12,000 feet with the camera tipped slightly forward so that the terrain directly below and slightly ahead of the plane would be seen. Superimposed on the lower part of the terrain were representations of navigation instruments so the examinee could perform dead-reckoning navigation or pilotage navigation. The instruments gave compass heading, speed, and drift correction, while numbers appearing on the film gave altitude and temperature. Many difficulties arose in the development of this test, but it was believed to be promising for future exploitation.

b. Radar

The Army Air Forces developed a comprehensive battery of standardized proficiency measures to be used in radar-observer training schools. The battery consisted of five progressive and final printed proficiency tests and six individual performance checks (18, 131-134; 9, 57-93). A split-half reliability coefficient of .80 was obtained on 200 cases for the final printed proficiency tests. One section of this examination was designed as a simulated radar-observer bombing mission requiring solution of navigational and bombing problems. Correlations between this section and three other sections measuring distinct skills ranged, for 3 samples of 200 or more cases, from .32 to .60. Intercorrelations of the sub-tests were about .45. Intercorrelations of the five printed proficiency tests were in the neighborhood of .35. Correlations with the performance checks were around .15. Thus the reliability of this program of proficiency testing was quite unsatisfactory. However, in the opinion of the personnel who supervised the radar-observer training schools, the introduction of these examinations had a very beneficial effect on the quality of instruction.

c. Gunnery

A flexible gunnery achievement test, making considerable use of pictorial items and reducing as much as possible the demand for verbal facility, was developed on gunnery problems for use as the final comprehensive examination in gunnery schools of the Army Air Forces (18, 134-136; 24, 99-117). This examination was found to have a reliability of .87, based on several samples totaling more than 6,000 cases. The average correlation for two samples of 1,000 cases between the weapon section of this examination and scores on a phase check on stripping and assembling of the caliber .50 machine gun was only .01. There is no data on the reliability on the phase check scores, but large proportions of the students received perfect scores, so that this validity coefficient has little meaning.

d. Radio Technician

A standardized Final Achievement Examination was developed in the Navy to implement the new pre-radio material and EE and RM curriculum (50, 331-343). The test consisted of the following parts: Mathematics, Electricity, and Mechanical Practice, with reliabilities for various forms of the test ranging from .84 to .87. The EE and RM Final Achievement Examination was established as a criterion to determine passed-failed marks in the EE and RM school, and the measure of validity was the degree of prediction of achievement in the third-level Radio Materiel Schools. Correlation coefficients between scores on the EE and RM

Final Achievement Examination in its various forms and marks at the end of the first month of Radio Materiel School are shown below as an indication of the test's validity.

TABLE 2

Correlation Between EE and RM Final Achievement Examination and Grades at End of First Month of Radio Materiel School

| School | 1 | | 2 | | 3 | | 4 | |
|---|---|---|---|---|---|---|---|---|
| | N | r | N | r | N | r | N | r |
| W | 98 | .59 | 102 | .55 | 90 | .64 | 88 | .66 |
| X | 293 | .38 | 273 | .52 | 293 | .53 | 317 | .65 |
| Y | 203 | .49 | 201 | .54 | 175 | .54 | 203 | .60 |
| Z | 177 | .52 | 184 | .59 | 170 | .69 | 198 | .70 |
| Average | | .47 | | .55 | | .59 | | .65 |

The increase in correlation with new forms, which were administered in chronological sequence, in the program indicates the effect of achievement examinations upon the instructional program. As long as the achievement examination included the necessary content of instruction, this effect can be considered good.

4. Academic Curriculum

Most of the war-time training units of the Armed Forces analyzed in various ways their achievement examinations in academic subjects, but little of this work is available as it was never written up for official report.

a. V-12 Comprehensive Achievement Test

The N-4, developed as a comprehensive achievement examination for V-12 students and administered at 131 V-12 Colleges, consisted of part-examinations in English, physics, mathematics, and history. Correlations for the separate part tests with the average grades in the V-12 College Training Program follow (50, 209).

TABLE 3

Correlations between Parts of the N-4 and Averages in the V-12 College Training Program

| N Test | Sample of 637 Students | Sample of 204 Students |
|---|---|---|
| Mathematics | .50 | .55 |
| Physics | .34 | .39 |
| English | .28 | .29 |
| History | .31 | .38 |
| Total | .49 | .53 |

The correlation between scores in this test for 1342 deck officer candidates in a class at a Naval Reserve Midshipman's School and final grades at the school was .54, and with graduation (bi-serial) .57 (50, 200).

b. Army Specialized Training Program

One of the most extensive analyses of academic achievement testing was made for the Army Specialized Training Program by the Personnel Research Section of the Adjutant General's Office of the Department of the Army. Reliabilities for the various educational achievement examinations in different subject-matter fields are reported (48, Vol. II, Section R), as follows:

TABLE 4

Reliability of Educational Achievement Examination Used in the Army Specialized Training Program

| Test | Reliability |
|---|---|
| Algebra | .69 |
| Geometry | .54 |
| Chemistry | .69 to .86 |
| Geography | .63 to .85 |
| History | .66 to .85 |
| Mathematics | .74 to .88 |
| Physics | .70 to .99 |
| Mechanics | .76 to .83 |
| Psychological Measurement | .52 to .79 |

These reliabilities probably indicate the extent to which specialized subject content can be measured consistently in ground instruction.

Also, indicated in the reports of the Personnel Research Section (48, Vol. II, Section R) are numerous correlations for these achievement examinations with such other variables as educational level, grades in various courses, classification test scores, and scores in other achievement tests. These correlations provide basic information for determining prerequisite and transfer content in establishing a ground school academic curriculum.

## D. VALIDATION OF TRAINING PROCEDURES (GENERAL)

One of the more startling findings pertaining to ground aviation training is the reliance that has been placed by those responsible for training upon "know-how," and the few attempts at validation of training programs and procedures. This is due to an attitude evidently transferred from civilian industry and education. That a training procedure trains at all, in the judgment of training officers, seems to have been an acceptable reason in most instances for its continued use in ground aviation training, as has been true for industry and education.

### 1. Problems of Validation

The effect of a training program in improving the knowledge content and skills of trainees seems self-evident. The trainees knew nothing or could do little before, and now they know and can do something. A training program may be criticized because it doesn't bring the trainees into operational billets with adequate knowledge or skills, according to obvious needs. Then the question is raised as to "why." This usually leads to discussion and reorganization of training, in content or in timing, to meet the more specific needs indicated by its critics.

#### a. Validation by Opinion

Validation of training procedures by other than opinion is seldom performed. For example, if the aviation students of Pre-Flight satisfy Basic instructors, the training program of Pre-Flight is considered adequate. If the aviation students of Advanced Training satisfy the Fleet operating officers, or are not too crude upon entering Fleet training, the training program of the Naval Air Training Command is considered adequate. There things rest. Questions are seldom raised in aviation training as to whether or not the trainee could have been trained --

in a shorter time, or<br>
with greater safety, or<br>
with fewer instructors, or<br>
through fewer class periods, or<br>
with differently organized content, or<br>
with greater proficiency, or<br>
at less cost, or<br>
with simpler devices, or<br>
in larger numbers, etc., etc.,

by some other procedure or procedures.

b. Statistical Procedure

Over-all validation by statistical procedures of a training program such as that of the Naval Air Training Command is seldom attempted because of the magnitude of the task. But the validation of specific procedures of the program can be made a continuous process and the effectiveness of the over-all can be interpreted from such data much better than from opinion.

c. Criteria

The difficulty of establishing significant criteria for the validation of a training procedure often seems insurmountable. An acceptable criterion must be considered important in the development of aviation skill, which usually means that it must be an "over-all" criterion representing the future goals of training. For a specific, and often minor, training procedure that is used at an early date in a training program to be significantly related to such a criterion would be a miracle. The best present answer for criteria in the validation of specific training procedures is to compare their effectiveness with controls at the time the procedure is used.

2. Program Validation

a. Comparison of Ground and Flight Records

It is not expected that ground school course records will correlate highly with flight records. An early comparison ($N = 176$) of achievement examinations and flight records in the Army Air Corps (42) showed negative or zero correlations for the following subjects: United States history, English grammar and composition, general history, geography, algebra, geometry, and physics. Only arithmetic ($r = .35$) and trigonometry ($r = .25$) showed positive correlations with flight records. The reliability of the flight records, of course, is highly questionable, and these records, at best, could not be accepted as an adequate criterion of effective aviation training. Thus such a comparison can mean very little in validating the training program.

b. Length of Training

A comparison was made by the Army Air Forces of a six- and an eight-week gunnery training course, both having the same objective (18, 171; 24, 304-315). The study was exhaustive in that it compared the training of the two courses over a considerable period and upon every available criterion, among which the following were included: scores on comprehensive examinations, phase checks, gunnery -- various ranges and trainers, gun camera exercises, ratings of instructors, student attitudes, and course grades. The results indicated that the eight-

week program had considerable advantage in student morale, a small advantage in immediate learning, but no advantage for permanent retention. In other words, the six-week course trained as efficiently as the eight-week course, and the only advantage for the eight-week course was that the students preferred it.

c. Spaced Practice

A study of two code-teaching schedules in radio training deals with the problem of spacing the practice (26). One group of code students, numbering 165 men, was given four hours of code practice daily throughout their prescribed eight weeks of low-speed radio operator training, concurrently with instruction in allied subjects. Another group, comprising 355 students, was taught code seven hours a day for five weeks, after which they received instruction in allied subjects only for the remaining three weeks of training.

The results indicate the superiority of distributed practice. When a correction is made for differences in elementary instruction and difficulty of test materials for the two groups, the four-hour men are found to have made as much progress daily as the seven-hour men, in spite of the three-hour difference in practice time.

This does not mean that four hours of code daily is the optimal amount. It is conceivable that three, or even two hours would yield good results, although a point of diminishing returns would sooner or later appear.

## E. STUDENT ATTRITION

Another approach to the validation of training is to study attrition, to answer such questions as —

Is it necessary to attrite at present rates in order to maintain standards?

Are the causes of attrition in the candidates or in the training program?

Where in the selection procedure can attrition in training be avoided?

Where in the training procedure can attrition be avoided?

What procedures might be included in the training program that would reduce attrition?

### 1. Statistics of Attrition

In an early attempt to determine causes of attrition in Officer Candidate Schools, tabulations were made in 13 representative schools of the Army with a total enrollment of 2625 (38). Reasons for attrition were as follows:

53 or 17% for academic reasons
175 or 56% for non-academic reasons
86 or 27% for personal reasons

314 - Total

Most of the "personal reasons" were sickness and "own request."

Statistics were kept on a typical group of applicants for aviation cadet training in the Army Air Forces. These applicants were sent to Pre-Flight after eliminations only for physical reasons (17). Of the 1143 men admitted, attrition was as follows throughout aviation training:

582 or 51% in primary flying schools
213 or 19% in basic flying schools
83 or 7% in advanced flying schools

878 or 77% during training

The 878 eliminated were failed for the following reasons:

99 or 11% for academic deficiencies in Pre-Flight School
591 or 67% for flying deficiencies at one of the three phases of training
65 or 8% at own request
122 or 14% for administrative reasons

From these and other statistics, it would appear that attrition in aviation training is greatest during early phases and, also, that failure in ground (or academic) subjects is a contributing cause of considerable importance.

2. An Investigation of Causes

A special study has been made of the reasons for attrition of 200 failing cadets in the Naval Aviation Training Program by comparing them with 200 graduated cadets (34). The Naval Aviation Training Program then consisted of four successive stages: The Naval Flight Preparatory Schools (NFPS); War Training Service (WTS); Naval Pre-Flight Schools (NPFS); and Naval Air Stations (NAS). The 200 failing cadets were a proportional selection of those attrited from 13 battalions in the three later stages of training as follows:

98 or 49% from WTS
13 or 6.5% from NPFS
89 or 44.5% from NAS

200 - Total

The official reasons given for the 200 failures were as follows:

1 or .5% for psychological reasons
139 or 69.5% for flight deficiencies
27 or 13.5% at own request
23 or 11.5% for academic reasons
9 or 4.5% for disciplinary reasons
1 or .5% for flight and academic deficiencies

200 - Total

The real reasons for attrition were sought in the comparison of the ground school training of the 200 failing and the 200 graduated cadets. The difference in ground school course failures between the two groups is shown below. In total number of course failures, the difference of 3.37% could not have been due to chance as it has a critical ratio of 4.81.

TABLE 1

Course Failures in Ground School of 200 Failing and 200 Graduated Cadets

| Courses Failed | Failing Group | Graduated Group |
|---|---|---|
| Navigation | 20 | 8 |
| Recognition | 2 | 2 |
| Engines | 1 | 0 |
| Aerology | 12 | 6 |
| Communications | 6 | 1 |
| Mathematics | 25 | 8 |
| Theory of Flight | 6 | 0 |
| Physics | 17 | 10 |
| Total | 89 | 35 |
| % of 1600 | 5.56 | 2.19 |
| Difference in % | 3.37 | C.R. 4.81 |

Fifteen percent, or thirty of the 200 failing students had met the CO's advisory Board of the Flight Preparatory School because of academic difficulties, whereas only 4% of the 200 graduated students had met the Board for the same reason. The difference of 11% has a critical ratio of 4.78 and could not have been due to chance. A grade-by-grade comparison showed differences in ground school subjects between the failing and graduated cadets as follows:

TABLE 2

Comparison of Course Grades in Ground School of 200 Failing and 200 Graduated Cadets

| Subject | Graduated Group Mean | Failing Group Mean | Difference | C.R. |
|---|---|---|---|---|
| Navigation | 3.19 | 3.03 | .16 | 4.00 |
| Recognition | 3.23 | 3.13 | .10 | 3.33 |
| Engines | 3.37 | 3.29 | .08 | 2.71 |
| Aerology | 3.09 | 3.02 | .07 | 1.94 |
| Communications | 3.84 | 3.66 | .18 | 3.22 |
| Mathematics | 3.26 | 3.19 | .07 | 1.50 |
| Flight | 3.25 | 3.15 | .10 | 3.16 |
| Physics | 3.18 | 3.12 | .06 | 1.38 |
| Gr. Trg. Average | 3.30 | 3.19 | .11 | 4.31 |

Thus, in all ground school subjects, the graduated cadets were superior to the wash-outs and, as indicated by the critical ratios, only in aerology, mathematics and physics could this have been due to chance.

Possibly the dichotomy, thought by many to exist between ground school success and flight success, is not what has been supposed. In the official reasons given for attrition, 69.5% of the failing cadets were washed out because of flight failure -- and 13.5% more on own request, but probably for the same reason. For only 11.5% was the official reason given as academic failure, thus indicating the unwillingness of training officers to accept ground school failure as a cause for wash-out. Yet the figures given above show ground school failure to be related consistently to attrition for whatever official reason given, and probably to be the underlying causes of flight failure.

Success in ground school might appear to be a prerequisite of flight success, but to look at it without bias toward ground or flight training, it might be better to think of success in ground school and flight training as related functions to be expected together in the same individual.

## 3. Peace-Time Training

Reasons for attrition in peace-time aviation training have been reported (35) for the Naval Air Training Command from statistics of 10 classes in 1947 and 22 classes in 1948, totaling 2,132 trainees. Three hundred sixty-two students were attrited out of this total of trainees at various stages in training, for reasons as follows:

TABLE 3

Analysis of Attrition in Peace-Time Naval Air Training

| Stage of Training | Ground Failures | Flight Failures | DOR and Others | Total | % |
|---|---|---|---|---|---|
| Pre-Flight | 204 | 0 | 64 | 268 | 74.0 |
| Primary | 10 | 42 | 19 | 71 | 19.6 |
| Instrument and Acrobatics | 5 | 9 | 6 | 20 | 5.5 |
| Tactical | 0 | 2 | 0 | 2 | 0.6 |
| Advanced | 0 | 0 | 1 | 1 | 0.3 |
| Total | 220 | 53 | 89 | 362 | 100.0 |
| % | 60.8 | 14.6 | 24.6 | 100.0 | |

Ground School was responsible for 60.8% of all failures during 1947-1948 in the training of Naval aviators, whereas there were only 14.6% flight failures during this period. In view of the fact that Pre-Flight ground instruction was responsible for 56.4% of all failures, it might be interpreted that a student surviving this obstacle had at least equal chances of surviving all other stages of Naval air training.

The subjects failed by the 204 failing Pre-Flight ground school students are listed below:

TABLE 4

Course Failures in Peace-Time Ground School Training, 1947-1948

| Subject | Number of Failures | % |
|---|---|---|
| Aerology | 89 | 22.8 |
| Navigation | 120 | 30.7 |
| Communications | 54 | 13.8 |
| Engines | 44 | 11.3 |
| E.N.S. | 15 | 3.8 |
| Gunnery | 24 | 6.1 |
| Principles of Flight | 8 | 2.0 |
| Survival | 33 | 8.4 |
| Others | 4 | 1.0 |
| Total | 391 | 99.9 |

From a review of this tabulation, it is clear where the teaching methods and procedures of study require most investigation and improvement.

This analysis of student attrition places the responsibility for failure in aviation training in large measure upon the ground school and the procedures established, such as instructor training and student selection, for making ground school training effective.

## F. MASS TRAINING

The training of large numbers at one time is a goal in which the Armed Forces are vitally interested. Experiments are now in progress to determine the value of various media for mass training. Among the most important under consideration are

Motion pictures (sound and silent)
Radio
Television.

The results of this research should be available within a reasonable period.

### 1. Face-to-Face Instruction.

The face-to-face situation in instruction has been explored quite extensively, largely in civilian instruction. Results of research regarding the effect of class size upon efficiency in learning may be summarized as follows:

| Form of Instruction | Maximum Numbers for Efficient Instruction |
|---|---|
| Pure lecture, with amplification | 100–500 |
| Lecture, with question-answer | 40– 50 |
| Discussion groups | 20– 30 |
| Quiz sections, for discussion and oral quiz | 10– 20 |
| Demonstration of visual aids | 5– 10 (or a number that can see and handle parts) |

When face-to-face instruction is augmented by motion picture or film-strip demonstrations, groups of any of the above numbers seem to function efficiently provided the seating is such that all individuals can see without a large amount of distortion.

### 2. Mass Training with Motion Pictures.

Motion pictures were used extensively for training purposes during the last war in most training programs of the Armed Forces. Their effectiveness in relation to other training procedures was seldom determined and their validation, as with other training procedures, was largely a matter of opinion. Theoretically, motion pictures have several advantages over various other forms of presentation of material in training. The motion picture can present a complete operation through slow motion, cut-away models, emphasis on parts, variations in timing. It has the advantage of showing situations from the subjective point of view, the camera taking the position of the observer who is faced with choice after choice in the learning. Essentially, the motion picture contributes realism to the learning situation.

a. Comparative Effectiveness of Motion Pictures.

An experiment was undertaken in the Army Air Forces (18, 185-189; 21, 241-254) to compare the over-all effectiveness, in ground training in aerial gunnery, of the training film and two other methods of instruction:

1) An illustrated lecture (oral instruction with visual aids)

2) Instruction through the reading of an illustrated manual (written instructions with visual aids).

The instruction was matched for content, except that the motion picture required only half as long in its presentation. The film, 15-minute presentation, was produced entirely by animated photography and the material was organized around a humorous story. The booklet presented the same content, employing advanced visual methods with a minimum of text and required 30 minutes for the reading. The half-hour lecture on the same subject matter was organized around a series of 19 lantern slides and delivered in an informal spoken style in which the class was questioned by the instructor. A 25-question examination was prepared for measurement of achievement in the learning; the odd-even reliability of the test was .63. A fourth group, which received no instruction, was also given the test. All groups were tested following the presentations and again two months later.

The results following training and two months later are shown in Table 1.

Table 1

Test Scores for Four Groups
Given Equivalent Training by Various Methods

| Method of Training | Time of Testing | | | | | |
|---|---|---|---|---|---|---|
| | Following Training | | | After 2 Months | | |
| | N | M | σ | N | M | σ |
| Film | 132 | 17.9 | 3.0 | 98 | 16.3 | 4.1 |
| Manual | 101 | 15.4 | 4.2 | 68 | 13.0 | 5.2 |
| Lecture | 101 | 15.2 | 4.6 | 86 | 13.6 | 4.9 |
| No Training | 122 | 5.4 | 3.1 | 24 | 7.0 | 4.2 |

The film group learned significantly more than the manual and lecture groups when tested immediately following training (critical ratios of 5.13 and 5.04 respectively), and it retained significantly more two months later (critical ratios of 4.5 and 4.1 respectively) No significant differences existed between the manual and lecture groups. All differences between training and no-training groups are, of course, significant.

It would be valuable to know if any of the three methods of training were more or less successful with superior or inferior students. To accomplish such a comparison, those examinees receiving scores in the top 30% and the bottom 30% were separated out from each of the groups. The results are shown in Table 2 below.

Table 2

Comparison of Test Scores for Superior and Inferior Students Given Equivalent Training by Various Methods

| Method Of Training | Time of Testing | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Following Training | | | | | | After 2 months | | | | | |
| | Superior | | | Inferior | | | Superior | | | Inferior | | |
| | N | M | σ | N | M | σ | N | M | σ | N | M | σ |
| Film | 40 | 21.3 | 1.3 | 40 | 14.3 | 1.6 | 34 | 20.8 | 1.6 | 30 | 11.6 | 2.0 |
| Manual | 30 | 20.1 | 1.2 | 30 | 10.3 | 2.4 | 19 | 19.0 | 1.2 | 25 | 7.1 | 2.9 |
| Lecture | 30 | 19.8 | 1.4 | 30 | 9.8 | 3.0 | 24 | 19.8 | 1.5 | 24 | 7.8 | 2.2 |
| No Training | 37 | 10.0 | 1.8 | 37 | 1.6 | 2.0 | 6 | 12.7 | 1.9 | 9 | 2.9 | 1.4 |

These results are quite startling: The differences in the learning and in the retention between the superior and the inferior groups taught by all methods are great indeed; but the differences noted before between the groups subjected to various methods of instruction have been increased for the inferior groups.

Table 3

Critical Ratios of Test Scores For Superior and Inferior Groups Given Equivalent Training by Various Methods

| Groups Compared | Time of Testing | | | |
|---|---|---|---|---|
| | Following Training | | After 2 Months | |
| | Superior | Inferior | Superior | Inferior |
| Film vs. Manual | 3.9 | 7.9 | 4.8 | 6.5 |
| Film vs. Lecture | 4.4 | 7.6 | 2.4 | 6.6 |
| Manual vs. Lecture | .9 | .8 | 1.7 | .9 |

Critical ratios indicated significant differences between the film group and the manual and lecture groups in all comparisons; however, the differences are much greater for the inferior groups. The superior learners learn by any method, although they do somewhat better when trained with films; the inferior learners, on the other hand, learn very much better by the film method than by the other two methods. Retention is of the order of the learning. The benefit of the motion picture instruction is greater for the inferior students.

b. Effect of Seating on Motion-Picture Instruction.

Thirty or more experimental studies were performed by the Army Air Forces to determine the effect of the viewing position upon motion-picture instruction (21, 51-58). The criterion used was performance in motion picture achievement tests. Various sized rooms were used, seating 25 to several hundred, and various aptitude and proficiency tests were administered.

The perceptual efficiency in viewing pictures was not affected by the viewing angle within a very wide range. Up to a 45 degree angle, there was no significant effect of viewing position upon any test scores. Two studies included extreme viewing positions, with angles up to 62 degrees, then 80 degrees. The study with an angle up to 80 degrees showed a significant decrease in efficiency measured from the center of the room only for those on one side of the room.

Distance from the picture was a different problem. Performance was better for certain tests when the observer was closer to the screen. These were tests in which the resolving power of visual acuity seems important in the judgments to be made. Subject to this limitation, it did not seem that perceptual efficiency in viewing motion pictures was affected by reasonable distance from the screen. But if a test is presented which has special requirements upon visual acuity, then the seating arrangement must be planned accordingly. The seating arrangement of a room for motion picture presentations has negligible influence upon most training, regardless of distance or angle. There is equivalent perception of screen presentations under any reasonable condition of seating.

3. Conditions of Mass Testing.

It is desirable to use the same media for testing as for instruction. Thus the question has been raised of whether or not large numbers can be tested effectively with motion pictures and whether or not testing can be accomplished under the conditions of illumination necessary for viewing motion pictures.

a. Motion Picture Tests

Motion picture tests were constructed in several areas of instruction in the Army Air Forces during the last war, and motion picture procedures for testing were judged to be effective (21, 99-112). The Aircraft Recognition Proficiency Test (Pre-Flight level) had an odd-even reliability of .89 and correlated between .55 and .74 with photo or slide examinations. Its successor, the Aircraft Recognition Proficiency Examination (Forms A and B) to be

used at all levels of recognition training had an odd-even reliability of .84. Other motion picture tests designed to measure proficiency in the Army Air Forces were "The Navigation Proficiency Test" (map reading and dead reckoning) and a "Target Identification Test for Bombardiers".

b. <u>Illumination of Writing Surface in Motion-Picture Testing.</u>

The effect of the level of illumination upon scores on tests given by means of motion pictures has been determined in the Army Air Forces (21, 58-59). Two-tenths of a foot-candle at the students' writing surfaces was considered satisfactory to write comfortably on the answer sheet, and with this illumination the screen image was judged to have lost little contrast. This condition for testing was compared with one in which the room was almost completely dark. The critical ratio of the difference between mean test scores for the two conditions was only .80. Thus the extremely low illumination did not appear to affect test performance.

Another experiment compared higher illumination of approximately 1.4 foot-candles on the writing surface with dim illumination of 0.1 foot-candles, a differential of 14 to 1. In the brighter condition, the screen image showed a noticeable loss in contrast. The higher illumination affected test scores favorably only slightly, significant at the 5% level.

It would seem that for motion-picture testing requiring the use of answer sheets, a wide variation in general illumination is permissable, and that there will be little effect upon visual perception of the screen objects or of the answer sheets.

## G. INSTRUCTOR TRAINING

Ground training units of the Armed Forces usually have had the problem of instructor selection as well as that of instructor training, whereas, with students, selection is performed elsewhere. As a result, instructors usually have been selected from the students graduating from training schools on the basis of their proficiency and adaptability to the school situation. Often during the last war, students were given instructor assignments immediately upon completion of their student training. Only gradually during the war were instructor training units added to student training units. The situation was similar throughout all forms of training in the Armed Forces, including aviation training.

### 1. Analysis of Instructor Qualifications

The selection of aviation instructors at the beginning of the last war was based on the assumption that an officer who graduated from an aviation training school was capable of becoming an instructor in that school. During the war, as the result of increased demand for instructors and criticism of instruction, both the Navy and the Army Air Forces initiated programs of study of the qualifications of good instructors, and particularly of flying instructors.

Descriptions of the characteristics of best and poorest instructors were secured from aviators who had completed pilot training in the Navy. The characteristics considered important in differentiating the best from the poorest instructors were given a rank order, according to frequency of mention. In the Army Air Forces, supervisory personnel and experienced instructors were questioned as to the qualities they considered most important in good instructors. Supervisory personnel were asked to rate instructors and then to describe the way in which the best differed from the poorest. In this way, lists of characteristics important in differentiating good and poor instructors were developed.

#### a. Qualifications of Flying Instructors

The qualifications of flying instructors most frequently mentioned by recently graduated students in the Army Air Forces schools (33, 290-1) centered around the following general aspects:

1) Not using ridicule, sarcasm, or abusive language. Students reported this form of instructor behavior increased their tension and difficulties.

2) Ability to express himself. Students reported they had difficulty when they could not understand what was expected of them.

3) Analysis of errors. Students reported they had difficulty when they could not learn exactly what was wrong.

4) Riding controls. Students reported they had difficulty in learning because the instructor took over on too slight provocation.

5) Interest in teaching. A frequent criticism was that the instructor lacked interest in teaching.

6) Self-confidence. Students reported that their instructors feared certain maneuvers or had bad habits which they passed on to them.

b. Instructor Qualifications

The results of the various studies of instructor qualifications (18, 139-161; 24, 337-350; 33, 289-299) agree fairly well in indicating the importance of the following main attributes which apply equally to ground and flying instructors:

1) Favorable attitude and suitable temperament.

2) Insight into training problems.

3) Ability to speak and express himself clearly.

4) Flying ability and confidence in himself and equipment.

5) Understanding of individual differences and learning principles and techniques.

Throughout the last war and in all Forces, the selection of flying instructors was based almost exclusively upon the fourth attribute listed above, flying ability. It would now seem that this should have not more than equal weight with several of the other attributes mentioned. Also, it was thought to be the essential qualification for ground instructors. Now flying ability is considered of secondary importance as a qualification for instructors in most subjects of the ground school curriculum.

2. Instructor Selection

Several studies concerned primarily with flying instructor selection are reported by the Army Air Forces (18, 140-161; 24, 337-381; 33, 389-351). Almost all methods of rating and testing were applied to this problem, including rating scales, background surveys, achievement and aptitude tests. The analysis of these results are quite suggestive for the development of selection and evaluation devices for aviation ground instructors.

a. Instructors' Qualifying Examination

Gunnery instruction in the Army Air Forces was divided into range, classroom, and air firing instruction. An

Instructors' Qualifying Examination was prepared for the selection of instructors in flexible gunnery from combat returnee enlisted personnel (18, 156-160; 24, 350-377). The aptitude measures are:

Booklet I

vocabulary, mechanical aptitude, mathematics, reading comprehension, spacial visualization, teaching aptitude, and personal adjustment

The achievement or gunnery knowledge measures are:

Booklet II

aircraft recognition, sighting, weapons, and turrets

The teaching aptitude and personal adjustment items discriminated best between individuals who obtained high and low ratings in practice teaching. Data on 800 subjects in Instructors' School in 1945 gave correlations as follows:

With Final Comprehensive Examination:

| | | |
|---|---|---|
| Booklet I | (Aptitude) | .57 |
| Booklet II | (Knowledge) | .62 |

With Teacher's Ratings in Basic Gunnery:

| | | |
|---|---|---|
| Booklet I | (Aptitude) | .24 |
| Booklet II | (Knowledge) | .12 |

With Ratings on Practice Teaching:

| | | |
|---|---|---|
| Booklet I | (Aptitude) | .19 |
| Booklet II | (Knowledge) | .08 |

Multiple correlations for various sub-tests of the Instructors' Qualifying Examination and criteria were as follows:

| | |
|---|---|
| Final Comprehensive Examination | .72 |
| Basic Gunnery Teaching Ratings | .25 |
| Practice Teaching Ratings | .32 |

It was clear from experience that the Instructor's Qualifying Examination, used for selection, produced a substantial improvement in instructor performance. But its measures predicted much better the course learning than later instructor performance. This has been the stumbling block in the selection of teachers for training everywhere, including civilian teachers' colleges throughout the United States.

b. Selecting Instructors in Civilian Schools

A battery of nine tests were constructed to select flying instructors at civilian contract primary schools in the AAF (10). This battery included tests of aviation information, reading comprehension, angular judgment, pedagogical judgment, and general intelligence. Ratings of teaching proficiency by instructor supervisors were found to be highly contaminated with the instructor's flying proficiency. But a detailed rating scale of 16 characteristics describing the instructor's analysis of errors, ability to express himself, interest in his job, conscientiousness, patience, etc., provided a criterion relatively independent of estimated flying proficiency and in which the various components of flying teaching proficiency were differentially measured. The nine tests of the battery predicted several of the ratings of the 16 characteristics, but failed to predict others.

c. Areas Measured in a Selection Battery

A battery of tests was developed by the Army Air Forces (36) for the selection of navigation instructors from returning combat navigators. It included areas of measurement as follows:

1) Survey of attitudes to reveal the degree to which attitudes and interests favorable to teaching were possessed.

2) Scientific background test of 60 multiple-choice items on various elementary scientific subjects to reveal the amount of general scientific knowledge possessed which was considered necessary as a basis for instruction.

3) Instructional Judgment Test of items requiring a decision upon certain teaching situations.

3. Criteria of Instructor Proficiency

The problem of criteria on which to validate instructor training becomes more difficult the more intangible the abilities or performances under consideration. Specifically, instructor training is difficult to evaluate because success in teaching is dependent upon much more in personality development than the knowledge and skills of superior performance in the area of instruction. There seems to be no satisfactory solution at present to this problem.

The following is an illustrative study. The Army Air Forces developed in-training criteria for navigation instructor's performance (36) as follows:

a. Instructor's Weekly Report, consisting of a rating scale on which the instructor-in-training is evaluated by his instructor.

b. Qualification Report, consisting of over-all ratings on course work and instructor qualities at end of course.

c. Instructor's over-all impression of instructor-in-training by quartile ratings in each separate class section.

d. Return combat navigator's rank in graduate school from among those desired to be instructors.

These in-training criteria showed unsatisfactory reliability with the exception of b.

On-the-job criteria to estimate navigation instructor performance consisted of a rating scale of fourteen items in which the teaching ability of the instructor is evaluated by his students, his co-workers, his supervisors, and himself. Intercorrelations of the different evaluations were quite low. Four of the five highest intercorrelations had fellow-instructors' evaluations as one of the variables.

4. Instructor Evaluation

The use of rating techniques for evaluation of instructors, either by students or supervisors, was widespread in all forms of training in the Armed Forces during the last war. These rating scales usually consisted of a number of variables presented in graphic form. The method of forced-choice performance description seems not to have been applied to instructor evaluation.

The use of rating technique in instructor evaluation is illustrated by a scale prepared to measure teaching proficiency of students under training as instructors in gunnery school of the Army Air Forces (24, 344-350). This scale included 14 items for low, middle, and high rating as follows:

appearance and bearing
voice
fluency
poise
logic
ability to express self
use of teaching aids
originality
ability to arouse interest of students
feeling between instructor and students
student participation in class
today's preparation
knowledge of subject
general effectiveness as a teacher

The reliability of instructors' ratings ranged for 8 raters from .76 on "ability to express self" to .94 on "general effectiveness as a teacher." It was decided that the ratings on "general effectiveness" would be used as the trainee's score in teaching proficiency, but that raters should complete the first 13 items for their training value.

It was at first recommended that 5 instructors perform such ratings on each instructor trainee, but in practice only two raters were used. Testing the reliability of two raters, a correlation of .90 was found for "general effectiveness," which was considered satisfactory for the use of this item alone as the score. With the passage of time, however, less attention was paid to the indoctrination of raters, and a later test of reliability for two raters gave a correlation for "general effectiveness" of .68. It was felt that it was the emphasis upon the training of raters that determined the successful use of the teaching proficiency rating scale.

5. Practical Instruction Techniques

A way to develop instructional "know how" rapidly, where dispersed and decentralized training is carried on, is to survey presently used procedures developed by individual instructors and to sift them by judgment of competent judges. This has not been performed for ground training. But a survey has been made of practical techniques for flight instruction (14) which may serve as a guide for a similar survey of practical techniques for aviation instruction on the ground.

The procedure of the survey consisted of inviting all flight instructors to describe any special teaching methods they felt were effective. The methods reported were submitted to experts for rating on a five-point scale of goodness. Standards for selection of techniques were set up which provided 30% of those originally submitted for use in preparation of a manual of suggestive techniques for flight instructors. These suggestive techniques have been published as a handbook for flight instructors entitled "The Tricks of the Trade" (48).

## H. TRAINING IN PERCEPTUAL ABILITY (VISION)

Practically every task in life requires training in the perception of objects and symbols. Much research has been performed on many specific perceptual tasks over the last 100 years, the larger share of which has been in the field of vision. From the point of view of use by the Armed Forces, recent research in the area of perceptual ability has been concerned with the problems of:

The nature of visual perceptual ability.

Perception of colored objects (color vision).

Night vision.

Visual requirements of military tasks.

Recognition of distant and moving objects, e.g., Aircraft

Recognition.

Perceptual conditions for hearing, e.g., Voice Communications.

Motor and kinaesthetic perception.

Most of the researches that have been performed in the areas listed above were primarily concerned with the problems of classification, recruitment, and assignment; with the problems of aptitude and proficiency measurement, and not with training. Visual perceptual research which may have application to ground training. with the exception of research on aircraft recognition training (which will be made the subject of separate section), will be discussed here. Perceptual training in voice communication and training in motor or kinaestnetic perception will be dealt with in following sections.

The eye is the most important instrument of contact with the environment and training in seeing in various situations, e.g., reading books, night seeing, radar observation, reading of dials and indicators, is necessary to secure adequate perception and comprehension. Such training for aviation, where effective, can be accomplished in large measure on the ground.

Lecture VIII, "How We See" of "Lectures on Men and Machines" (7), discusses the various visual functions, including visual acuity, eye movements, day and night vision, glare and illusions; and it discusses the laws of vision generally from the point of view of use of this information in Naval operations.

1. Visual Perceptual Ability

The Applied Psychology Research Unit at Cambridge, England, was concerned during the war with the problem of the generality of visual perceptual ability. If there were different factors or areas of perceptual ability in which training could be carried on and from which transfer would be considerable to specific learning, knowledge of these areas would be of great assistance in planning basic courses for ground instruction in aviation.

An experiment (55) was performed with 20 airmen in England to determine if there existed a unitary perceptual ability for different subject matter consisting of a). silhouettes of objects, b). shapes, such as a star, c). block letters in various planes, d). geometrical designs and e). drawings of household utensils. Correlations between "perceptual ability" for the different materials were inconclusive, due possibly to homogeneity in ability of the group. Also, it may have been due to background differences in the several areas of perception, because naming of the stimuli was necessary. While the experiment gave negative results in solution of the problem of whether or not there is a general perceptual ability, it verified what is a general conclusion in training -- that background contributes to differences in perceptual ability.

Similarly the perceptual ability of 30 R.A.F. pilots was measured (31) for a). silhouette pictures, b). fantastic pictures, c). geometrical shapes, d). complicated curves, e). block letters, f). scales and dials. Examination of the inter-correlations suggested that two unrelated types of ability were operating in the observation of these figures. One was the determination of shapes, and particularly of small details of these shapes. This ability was unrelated to scores in general intelligence. The second was the assimilation of particular shapes to broad general categories, or a factor of generalization. This ability was related to scores in general test performance. Subjects seemed to stress one ability at the expense of the other, although there were those good or poor in both.

Such exploratory research, aiming at determining if there are unitary factors or kinds of perceptual ability, while of possible future productivity, has nothing to contribute to training at present. The perceptual ability existing at the pilot trainee level has been established by previous training. Whatever area of perception is used in this training should be tested to determine the base for future training, as has been indicated for subject-matter reading ability. According to present knowledge, prerequisite background required for training is the best indicator of present perceptual ability.

2. Color Vision

Extensive research has been carried on at the U. S. Naval Submarine Base, in its Medical Research Laboratory, upon color vision requirements for Naval tasks. This work applies essentially to the selection, classification, and assignment of military personnel.

Concurrent with these researches, the practical question has been repeatedly raised as to whether or not there might be corrective training for deficient color perception. Lt. Commander Dean Farnsworth, Director of the Color Vision Laboratory at New London, presents the consensus of authorities (8, 15, 16) that no cure for color-blindness exists, nor is there any training device for mitigation of the deficiency. That it might be clear what is offered for "color-blind training" by commercial agencies, the following are listed by Farnsworth:

- Repeated observation of bright colors
- Subcutaneous injection of iodine
- Electrical stimulation of the eyeball
- Warming of one eye
- Making of color judgments
- Observation of red and green lights
- Viewing of dazzling lights through red, green, and purple goggles
- Viewing flashing lights of various colors
- Dosage with extremely large quantities of vitamins
- Injection of cobra venom
- Repeated coaching on color blind tests
- Continuous wearing of tinted glasses

Thus far, there is no known form of training that improves color deficiency.

3. Night Vision

It has been established that individuals differ with regard to night vision, but it is also recognized that training will improve the ability to see at night. Usual methods of training in various branches of the Armed Forces (44) have included:

- Instruction in off-center fixation
- Instruction in scanning procedures
- Teaching methods of establishing and maintaining dark adaptation
- Instruction in use of night vision aids to protect dark adaptation, e.g., red goggles

Instruction in perceptual cues for recognition
of objects at night (also when camouflaged)
Training in military duties at night

a. Peripheral Vision Training

A method of ground training of peripheral vision has been investigated in which the requirements were 1) forcing of peripheral interpretation and 2) exposing stimuli long enough for the subject to work out his interpretation (43). The procedure included a hand-operated perimeter and test objects consisting of Landolt rings, airplane silhouettes, and isolated forms. Training by this method with 43 Naval and civilian students at the University of North Carolina showed an improvement in peripheral vision over the starting score of 334%. After training, it was necessary to stimulate retinal area only one-eleventh the size necessary before training. Or, in other words, after training, eleven times as much detail could be perceived if the same retinal areas were stimulated as before. This improvement transferred to other areas of the retina, to night vision acuity, to unfamiliar test objects and conditions outside the laboratory.

b. Autokinesis in Night Vision

A problem particularly important in night vision is the effect of apparent movement (autokinesis) upon observation of other objects or airplanes. A series of experiments on 500 aviators was carried out both in the laboratory and in formation flights at night to study the phenomenon of autokinesis (23). These experiments showed the characteristics of apparent movement of an object in the visual field (autokinetic illusion) to be as follows:

A universal experience of all normal people
Onset of movement preceded by about nine seconds of fixation
Duration of movement in a particular direction about 10 seconds
Movement observed about half the time of observation
The rate of movement being slow
Angular displacement for most movement being considerable
Movement occurring in all directions
Voluntary control of movement limited

Training methods recommended as a result of these experiments should include:

1) Showing the aviator the nature of the illusion
2) Practice in using fixed objects as a reference point
3) Practice in interrupting steady fixation periodically for at least 10 seconds
4) Practice in reliance on instruments wherever perception is in conflict

## 4. Visual Requirements of Military Tasks

The Army-Navy-NRC Vision Committee was organized in 1944 to coordinate research of all types in the field of vision. A basic problem was to determine the relative importance of visual acuity, as measured by opthomological tests, and visual perception, as measured by psychological tests in various military jobs.

First, it was necessary to determine actually what was visual acuity in view of the medical requirements which had rejected 7.8% of all inductees for eye deficiency during the last war. Upon request of various medical departments of the Armed Forces, the Personnel Research Section, Department of the Army, initiated research to determine what was measured by present visual acuity tests and what were the requirements upon visual acuity as measured by the various military occupations (45, 46, 47).

Present results of this research program have indicated what tests measure best the resolving ability of visual acuity. Resolving ability is the most important factor in visual acuity and the one most influencing accurate visual perception of shapes at various distances. Several other visual abilities were found to be measured by the tests, and among them, the next in importance was brightness discrimination. These two factors, resolving power and brightness discrimination, contributed most in determining how well an individual sees letters and other objects. They define visual acuity as measured by present tests.

### a. Illumination and Brightness Discrimination

Comparisons of visual threshold and perceptual ability, depending upon vision, have been made by the Applied Psychology Research Unit of Cambridge University, England (2). It was found that where observers with different brightness thresholds were given the intensity of illumination necessary to see adequately, their perceptual ability was equal. Evidently one of the factors measured in visual acuity tests, i.e., brightness dicrimination, has no effect upon visual perception as long as illumination can be controlled.

b. Visual Acuity and Perceptual Ability

A healthy scepticism seems warranted in attributing too high a value to visual acuity in the performance of most visual tasks. Other than for those individuals with most obvious defects in visual acuity (who are screened out long before the student gets into aviation training), any deficiency in visual perception is unlikely to be due to visual acuity. Much better to look for reasons for low achievement in training resulting from such causes as habits of slow reading, low motivation or lack of prerequisite knowledge, than to deficiencies in visual acuity.

5. Visual Training Methods

Highly specialized training programs in visual perception were developed during the last war in Aircraft Recognition and in Radar Observation. Aircraft recognition training is considered in the following section.

a. Radar Observer Research

Radar Observer research during the last war was concerned primarily with problems of aptitude and proficiency measurement of observers. Numerous preliminary investigations were carried on at the request of the Army and Navy by the Office of Scientific Research and Development upon the nature of the job of radar observation in ground, Naval vessel and aircraft radar installations. The Army Air Forces carried on job analyses and developed tests of aptitude and proficiency for air-borne radar observers (51). It initiated a selection program for potential radar students and was concerned with problems of proficiency criteria and the conditions of efficient use of trainers and training methods at the close of the last war (9).

b. A Special Training Method

A trial was made in flexible gunnery training by the Army Air Forces (24, 245-249) of a method of visual training, developed by Hoyt L. Sherman (Ohio State University), for which the rationale was that the method would enable the gunner to do two things better: first, to perceive each detail of his visual field in accurate relationship to all other details, and to do this very rapidly and automatically; second, to see apparent motion and determine apparent position of planes in his visual field without the need for moving his eyes. The training was conducted in groups of 20 students before a 12' x 12' screen on which was

projected at exposures of about 1/20th of a second non-geometrical forms embodying changes in size, brightness, number of elements, and plane of projection. The students were required to reproduce these forms quickly by drawing sketches. The students wore masks which prevented them from seeing their work; and as the training progressed throughout 24 sessions of 30 minutes each, the students were moved closer and closer to the screen, thus increasing the angle of vision required.

The trial of this training procedure was made on three randomly selected groups of 40 flexible gunnery students each: 1) a drawing group, which received full training; 2) a non-drawing observation group, which received the training with the exception of performing the drawing; and 3) a control group. All were pre-tested and post-tested on three operational training criteria: skeet, turret tower, and Jam-Handy Trainer shooting, and on two tests: a speed of identification test and a plane formation test. On the Jam-Handy, the drawing and control groups were significantly better than the non-drawing group; on the turret tower, the non-drawing group was significantly better than the drawing group; on speed of identification, the control group was significantly better than the drawing group. No other significant differences appeared in the statistical analysis. Also, there were no reliable differences in the scores made by the three groups in aircraft recognition at the end of this course.

From these data it was concluded that Sherman's method of training of visual perception was not of practical value in increasing gunnery proficiency. Of course, there is a practical question here of whether or not these evaluation criteria were related closely to operational gunnery, which was not determined. The intercorrelations between these criteria (24, 175-177) are all very low, suggesting that not more than one, if any, of these can be good operational criteria.

6. Visual Fatigue

It has been thought possible that increased blinking under fatiguing conditions might reduce accuracy of visual observation. An experiment has been performed in the Applied Psychology Research Unit, Cambridge, England, on 20 Naval ratings over a two-hour period in which the errors in reading a clock and the number of blinks were recorded (5). Previously, it had been shown that clock errors increased with time. The shape of the curve showing the increased mean blink rate was similar to that of the increase in reading errors. Yet, never was there coincidence of a blink in any of the 151 misses in a total of 950 readings. Thus, it seems that while blinking increases with time in visual observation, as does errors in reading, the relation is not correlative.

I. AIRCRAFT RECOGNITION TRAINING

Aircraft recognition became a major unit of the training program in practically all Armed and Civilian Forces of the last war. This training had the goal of improving direct visual perception of aircraft in the sky, either for purposes of spotting and plotting on the ground or for identification and gunnery from a plane.

The first courses in aircraft recognition were set up early in 1940 by the British Anti-Aircraft Command, and its system of training included instruction in the nature and characteristics of military aircraft and training in identifying pictures of them by their shape and size.

Early aircraft recognition training in the United States followed the British pattern. Training was by looking at pictures or silhouette views and associating them with the name of the plane. A system of terminology for the detailed shape-characteristics of the plane was developed supposedly as an aid in memorizing. This was called the WEFT System," and was based on the major elements of a plane — its wings, engine, fuselage, and tail. Defects of this system were apparent. It emphasized verbal memorizing of parts — and only parts that were namable — and not visual recognition of the plane; and it neglected actual practice in the act of recognition.

1. The Renshaw or Flash System

A school for Navy instructors in aircraft recognition was organized in 1942 by Dr. Samuel Renshaw at Ohio State University. This emphasized the necessity of visual learning of planes by their shapes through repeatedly observing images on a screen in flash presentation, for which recognition could be tested. This procedure was adopted both by the Navy and Army, and it was known in the Navy as the "Renshaw System," and in the Army Air Forces as the "Flash System of Instant Recognition."

The assumptions of this training were:

a. that the aim was to develop instant recognition.

b. that this could be accomplished with increasingly shorter exposures (as fast as 1/100th of a second).

c. that the method of flash exposures forces the student to perceive total form.

d. that training with transfer material improves perceptual efficiency.

The first course in aircraft recognition in the Army Air Forces consisted of 30 one-hour sessions spaced over 9 weeks. It included training with 4 digit to 10 digit slides for improving span of perception, training with counter slides of 3 to 30 distant aircraft for practice in estimation of numbers, and training with slides of 40 different aircraft, preceded by discussion of their characteristics for practice in aircraft recognition. The level of proficiency to be attained, as stated

in the AAF 1943 manual, was identification at 1/75th of a second.

The Renshaw or Flash System of aircraft recognition training was modified considerably by both the Navy and Army Air Forces during the war. But in its use throughout the war, the method of flash presentation was retained as the essential element of the training.

This method of training had been set up without a job analysis of the recognition task or tasks. It was not true usually in operations that instantaneous recognition was necessary. For example, airplane gunners do not recognize first and then fire. They either fire or withhold fire on the basis of whether or not the other plane attacks, plus their set from previous identification. In any case, the usual situation in the last war was systematic scanning and leisurely observation at great distances of any airplanes.

Critical arguments against the use of the Renshaw or Flash System from the point of view of what is known of the task of aircraft recognition in the last war are:

a. Training to maximize distance of recognition to allow for reasonable leisure in operational recognition situations was far more important than training in instantaneous recognition.

b. Training in scanning was a more realistic procedure for most recognition situations than fixation of the center of the projection screen n preparation for a flash image.

c. Training in observation and interpretation of plane behavior was more applicable to making a decision as to immediate action than was training in instantaneous recognition.

d. Each recognition task -- e.g., civilian spotting, gun placement observation, blimp observation, plane gunner action -- required differential training in aircraft recognition.

If there had not been practical modifications of the formal training procedures of the Renshaw or Flash System "on-the-job," it is probable that aircraft recognition would have been considerably more faulty during the last war, due to lack of appropriate training, than it was.

2. <u>Analysis of the Renshaw or Flash System</u>

Once the Renshaw or Flash System had been set up as THE training procedure in aircraft recognition, the practical question remained to be answered as to whether or not it actually facilitated aircraft recognition.

a. Learning Accomplished

It was evident to all that learning actually occurred in the training. The difference between pre-test and post-test scores demonstrated this consistently. Tested proficiency showed 100% improvement where a nine-hour course was offered with time equally distributed in practice on inclined engine, radial engine, and twin-engine planes (24, 253-254). This training in aircraft recognition appears to obey the laws of learning, forgetting, and relearning. When men came back into the pilot training program of the Navy, where their training had been interrupted for a period, and they took up aircraft recognition training where they had discontinued it, after a short period their work in the course was indistinguishable from other men in the course who had not been interrupted in their training.

b. The Effectiveness of Different Exposure Times

The effect of exposure time in the training has been tested by the Army Air Forces, with the view of checking upon the assumption that flash presentation facilitated the learning in the aircraft recognition courses (18, 178; 21, 124-28). Three groups of about 160 students each were trained in the standard 30-hour course of the AAF with the same number of exposures, but with different exposure speeds, as follows:

| | |
|---|---|
| Fast | 1/50th second (gradually attained from 1/5th) |
| Intermediate | 1/10th second (following 1/5th) |
| Slow | 1 second throughout |

All groups were equal at the end of the course in scores in the Aircraft Recognition Proficiency Test. As measured by slide tests at exposure rates of 1 second, 1/10th of a second, and 1/50th of a second, differences were unreliable between the three groups for the 1 second and 1/10th of a second exposure. Only in the 1/50th of a second exposure was the "fast" group significantly superior to the "slow" group.

It appears that the Flash System of decreasing exposure time in the learning contributed very little to aircraft recognition scores at the end of the course.

c. Emphasis on Total Form

The Flash System aimed at perception of total form. But usually in the orientation, instructors found it difficult to discuss the airplane except in terms of its features, which was considered bad pedagogy. To settle this issue, an experiment was performed in the Army Air Forces (18, 178-79; 21, 128-31) contrasting the two approaches, one involving emphasis on learning the total forms without

reference to their features and the other involving the learning of a standard set of features. Two matched groups of about 90 students each in the standard 30-hour aircraft recognition course had this difference in the instruction. Both groups were about equal at the end of the course, but with the probabilities in favor of greater learning for the feature-emphasis instruction. The mean test scores of the feature-emphasis instructed groups were always slightly higher. The critical ratio for the difference on the Aircraft Recognition Proficiency Test was 1.49, and on the final slide recognition examination it was 2.44.

There would seem to be no advantage accruing to the effort often made to preserve a Gestalt point of view of observing total form at a premium of not telling the student what he wants to know about the difference in features between planes.

d. Special Perceptual Training

The original Renshaw or Flash System included supplementary training in visual perception with digit slides of from 4 to 10 digits and "counter" slides of from 3 to 30 planes, presented at increasingly rapid exposures. Digit training was aimed at widening of the perceptual angle and "counter" training at accurate perception of numerousness. This general training was thought to transfer to aircraft recognition.

A series of experiments was planned by the Army Air Forces to determine the effect of digit and counter slides on, first, proficiency in aircraft recognition, and, second, on a general perceptual requirement, the span of attention (18, 179; 21, 131-36). Two groups of about a hundred students each, equated in knowledge of airplanes, were compared. One group was given a 12-minute period of digit and counter training for the first 10 class hours of the 30-hour standard course in Aricraft Recognition. The other group was occupied during the 12 minutes of these 10 class hours with unrelated instruction, so that the compared groups were equal in aircraft recognition training at the end of the 10 class hours. Thus for the first group an additional one-quarter of the available recognition training time for both groups was spent on the digit and counter training which was considered to be transferable to aircraft recognition.

Digit and counter slide tests were administered to the two groups at the end of the 10 class hours, with the expected result that the digit and counter trained group were significantly superior. But, when tested on a recognition slide examination and on the Aircraft Recognition Proficiency Test, both groups made almost exactly the same scores (critical ratios between groups of .31 and .10, respectively). It seems evident from this that special

digit and counter training had no effect upon aircraft recognition. There was no transfer effect according to the purpose of this special training.

The two groups were tested with a "Flexibility of Attention Test" to determine if there was transfer to other important areas of perception. Again the results were negative. There was a critical ratio for the difference between the two groups of .21.

The hypothesis of the Renshaw or Flash System of improvement of perception (other than in the area of training) through practice in flash perceiving with the digit and counter slides is not supported in experiment. As in other instances of this kind, special transfer is not realized according to theory. It is usually far better, without evidence to the contrary, to train in the desired performance rather than in other activity.

e. Actual Aircraft Recognition

Opinion supported the contention throughout the war that aircraft recognition training was both necessary and valuable in military operations. But no attempt was ever made to establish an operational criterion for validation of any form or kind of aircraft recognition training. Opinion supported the change from the WEFT System to the Renshaw or Flash System early in the war. Now opinion favors drastic modifications of this system.

3. Instruction Research

Research upon various instructional procedures has been carried on in connection with the Aircraft Recognition Training Program of the Armed Forces. The results of this research have wider application to other perceptual training.

a. Effect of Seating in Classroom

A study was made of the influence of the location of students in relation to the screen in aircraft recognition training (24, 249-52). Angular distance or distance from the center of a room seating 80 students had no significant effect upon examination scores. But the absolute distance from the screen, which varied from 12 to 36 feet, noticeably influenced the score.

b. Drawing as Indicative of Recognition Ability

In an attempt to determine if drawings of airplanes could be used as a measure of proficiency in aircraft recognition, the Army Air Forces carried on an experiment in which 196 Pre-Flight students who had completed the 30-hour training

course in aircraft recognition made free-hand drawings from memory of eight airplanes selected from those which they had been trained to observe (18, 178-80; 21, 130-45). Adequacy scores for these drawings correlated .61 with final course grades. (The reliability of the course grades was .85 and of the adequacy scores .78.) Ratings of draftsmanship of these drawings correlated .37 with course grades and .54 with the adequacy scores. With the adequacy scores partialed out, the relationship of draftsmanship to course grades dropped to .07. Ability to draw airplanes and their recognition have a sufficient relationship for drawings to be used as a measure in evaluating proficiency in aircraft recognition.

Composite drawings were constructed by averaging by eye several tracings on translucent paper, and it was discovered that as few as 25 drawings were sufficient to yield a composite representative of the full population. This was true of the three views used of each of the planes. The composites and the great majority of the original drawings had the main visual characteristics of the planes they represented. There were, however, consistent differences between the composites and the actual shape of the plane; a "constant error" existed in drawing the plane. In many instances the differences were enlargements or exaggerations of those features of the shapes believed by the instructors to be characteristic of the plane.

c. Active Learning

Training specialists generally recognize the principle of participation as a motivating force in learning. To test its effect in aircraft recognition, the Army Air Forces set up an experiment in which two groups, consisting of about 150 Pre-Flight students each, were trained in the recognition of planes, one under passive conditions and the other under active conditions (18, 180-1; 21, 145-49). To equate for knowledge of planes, slides of unfamiliar foreign planes were used. The passive learning group viewed the slides for 3 trials with 5-second exposures in which the name of the plane was announced before and repeated while the plane was on the screen. The active learning group had this same form of presentation for the first trial. For the second and third trials, the plane was presented for 2.5 seconds, after which time was allowed for writing its name. Then the plane was presented again for 2.5 seconds and its name was announced for checking a correct response or writing the correct name. The test consisted of writing the name of the plane following its exposure for 2.5 seconds. Learning time, thus, was equated for the two groups. The active learning group was decidedly superior — on the average, 139% of the passive group — and the critical ratio for the difference between the two groups was 7.69. Learning to recognize airplanes is markedly facilitated by such overt reinforcement of the learning.

d. Similar or Dissimilar Presentation

Courses in aircraft recognition during the last war usually included slides of three or more attitudes of approximately 40 planes, representing four nationalities and three classes: four-engine, twin-engine, and single-engine. Various methods were used in the presentation of these materials to minimize confusion.

An experiment was conducted by the Army Air Forces with two training sequences: one sequence of two dissimilar planes of the same nationality; the other of two similar or confusable planes, irrespective of nationality (18, 181-82; 21, 149-52). Two equated groups of approximately 90 students each were taught by one or the other procedure in a 26-hour course in aircraft recognition. On the final slide examination, the group taught by the method of similarity was slightly superior, but the difference between the two groups was unreliable (C.R. = 1.01). On the Aircraft Recognition Proficiency Test, again the group taught by the method of similarity was slightly superior, but the difference between the groups was unreliable (C.R. = 1.17).

4. Perception of Aircraft at a Distance

Slides available early in the last war for aircraft recognition training were largely photographic close-ups of aircraft. The first method devised to simulate distance was a progressive decreasing of size of the picture flashed on the projection screen, by moving the projector closer. It became evident, however, that in doing this the student did not see the airplane as more distant, but merely as smaller. A second method, using slides, decreased the size of the airplane in the picture, i.e., in relation to the surround of sky or clouds. The pictures of planes were made of a size to subtend visual angles equivalent to those for planes at a prescribed distance. In practice this method of simulating distance was considered to be superior to the former. A third method was to increase the distance at which the student viewed the screen, i.e., to arrange seating in the classroom to simulate distance. Among others suggested was one to project steroscopic images to give the impression of distance.

a. Determining Apparent Size of Airplane

As objects move away from an observer, the retinal size of their image decreases as the square of the distance. The methods of simulating distance described above are based largely on this physical fact. In this it is assumed that the perceived distance of an object is dependent on the size of the retinal image. This assumption is not in accordance with the psychological facts. Apparent size of familiar objects is relatively constant regardless of the distance of the object from the perceiver. An object's perceived

distance will increase as the actual distance increases (or as the retinal size of the object decreases). But its perceived size will remain relatively constant. Thus, the physical facts, on which range recognition training was based, and the psychological facts are in conflict.

This required a test to determine what existing methods were feasible in aircraft recognition training. Choosing the two most commonly used methods:

1) different sizes of planes in the surround of slides

2) different distances of observers from the screen

to simulate distance, the Army Air Forces set up an experiment to check on methods of aircraft range instruction (18, 182-83; 21, 152-60).

The experiment was arranged to compare slides of unfamiliar foreign aircraft, of which the total projected areas were constant and the backgrounds clear, but on which there were three different sizes of planes as follows:

1) Large size - plane covered most of total frame

2) Medium size - plane covered 5/8ths of total frame

3) Small size - plane covered 1/2 of total frame

The slides were presented in controlled order, to compare distances of observation, a three distances from the screen: 10 feet, 20 feet, and 40 feet. Average estimates in yards as a function of the viewing distance and size of the pictured plane are shown in Table 1.

TABLE 1

Average Estimate (Yards) as a Function of Viewing Distance and Size of Pictured Plane

| Viewing Distance | L-Slide | | M-Slide | | S-Slide | |
|---|---|---|---|---|---|---|
| | M | σ | M | σ | M | σ |
| 10 feet | 206.2 | 213.4 | 313.8 | 224.2 | 413.8 | 289.8 |
| 20 feet | 201.6 | 196.3 | 356.5 | 254.4 | 466.3 | 274.7 |
| 40 feet | 234.5 | 21[illegible].3 | 407.2 | 265.7 | 556.0 | 276.9 |

As the measured size of the "large," "medium," and "small" planes on the projected picture decreased from unity to 5/8ths and to 1/2, the distance would be expected (according to the law of the visual angle) to increase in the proportion of 1:1.6:2. The mean estimates actually did rise in a ratio

of 1:1.7:2.2. This is approximately the expected inverse relationship between the size of the plane within a fixed picture frame and the impression of distance.

Viewing the slides at different distances, however, did not affect the estimates of size of planes as would be expected from the different sizes of the retinal images. If the estimated distances were determined by the size of the visual angle, they would be expected to increase in a ratio of 1:2:4. The actual mean estimates viewed at 10, 20, and 40 feet rose in the ratio of only 1:1.1:1.3.

An additional attempt was made in the Army Air Forces to produce a slide that would simulate a 300-yard range. A ring representing a 70 mil sight reticle was included in proper proportions with a small picture of an airplane. It was expected that this method would reduce the influence of the size constancy phenomena. It was tested upon 240 basic gunnery students paired by pre-tests into two groups (24, 252-55), one of which was administered 7 close-up views of 26 planes followed by 7 simulated 300-yard views; and the other, 14 close-up views. The post recognition test of 1000 yard views showed no significant difference in scores between the two groups.

The evidence reviewed above shows that, of the methods tested, the one simulating distance by varying the size of the plane in the picture would be the most likely to prove of an advantage to training. There is, however, an important item in the results above that is disturbing to the drawing of this conclusion. The individual differences in estimation of distance, as are indicated by the standard deviations in the table, show that even this method will have a highly variable influence in the training. Most subjects estimate far too little or far too great distance to be considered reasonably accurate.

The use of pictures to simulate distance in aircraft recognition is subject to psychological influences not very well understood. These influences are so great that it would seem inadvisable under present forms of instruction to expect students to learn range-estimation of aircraft with pictorial material. This conclusion is inevitable from the experimental evidence and until more can be learned of the psychological variables operating. There is no satisfactory device nor method in sight for effective instruction of distance perception in aircraft recognition.

5. Conditions Affecting Recognition

The conditions of observation of aircraft -- whether from the ground or from a plane, whether below clouds or in a cloudless sky, whether by day or by night, whether of a plane in one attitude or in another, and so on -- affect the accuracy of perception and are necessary considerations for training in aircraft recognition.

a. Atmospheric Conditions

Chapanis (6) reports the affect of atmospheric contrast at night in the observation of aircraft, summarizing data from a British source. The average ranges for spotting aircraft at night under winter skies in Britain is given below for various conditions of observation:

| | |
|---|---|
| Full moon, no clouds (aircraft seen from below) | 1200 ft. |
| Moon on cloud floor (aircraft seen from above against clouds) | 6000 ft. |
| Moon on cloud floor (aircraft seen from below against clouds) | 500-700 ft. |
| Dark clear starlit night (aircraft seen from below) | 600-900 ft. |
| Dark clear starlit night (aircraft seen from above overland) | 300-400 ft. |

Under the best conditions at night when the contrast is greatest, when the aircraft is seen from above against a cloud floor and with full moonlight shining on the cloud floor, an aircraft can be spotted at a distance of a mile. Under the worst conditions of night observation, where contrast is the least, when the aircraft is seen from above overland on a dark clear starlit night, the aircraft can be spotted at only a twentieth of this distance. These are spotting results, of course, and not recognition results.

b. Distance of Recognition

Actual measurement of distance of recognition during the daytime is, of course, impractical, but it is possible to study the problem in miniature -- employing models and proportional distances for actual planes on the assumption that size-distance relationships intercepting the same visual angle on the retina of the eye would be equally recognizable. Research in visual acuity supports this assumption that the identification of an object is about the same when small or near or when proportionally large and far -- within the distances up to about 100 feet on which tests have been made.

The Army Air Forces set up an experiment on this assumption, using standard airplane models of known scale, in order to determine identification of aircraft in various attitudes at proportionally greater ranges (18, 182-85; 21, 160-68). Three hundred seven aircrew men with 30 hours training in airplane recognition were asked to identify 6 models of well-known airplanes when brought in from 96 to 12 yards, for which the equivalent proportional distances for the actual planes were 4 miles to 1/2 mile. The scale of

models to planes was 1:72. The aircrew trainees were divided into four equal groups, each group viewing the models in one of four different attitudes: quarter-front below view, head-on view, plan view, and passing view. The results indicate that recognition depends upon the attitude of the plane, the head-on position being most difficult and the quarter-front below position easiest.

Results depended upon the size of the plane, as would be expected -- the larger planes being more frequently correctly identified at a given distance. Recognition of the smaller planes varied more according to their attitude than did recognition of the larger planes. The smaller planes were not recognized 100 percent in all attitudes even at 12 yards (the equivalent distance for 1/2 mile). Table 2 shows the percentages of correct identification of six aircraft in four attitudes at each of six distances. In general, the values for the percentages of correct responses resemble expected psycho-physical measurement for distance perception.

It must be kept in mind, however, in interpreting from these data that acuity at the distances proportional to those represented in the experiment may be reduced due to the factors of atmospheric haze and background contrast, as has been indicated earlier in this section for night spotting. This will be true even on a clear day and, as visibility worsens, recognition will be decreased markedly. Glare (the models were black and planes are silvered) is an additional factor reducing recognition. All of this implies that recognition at actual distance is likely to be considerably reduced from that reported here as determined by recognition of models at proportionally shorter distances. It is unlikely that recognition will ever be greater than indicated for the models. It is evident that only under most favorable circumstances will aircraft be recognized with the naked eye at distances equal or exceeding the firing range.

Table 2

PERCENT OF CORRECT IDENTIFICATIONS

| Plane | 12 yds* | 24 yds* | 36 yds* | 49 yds* | 73 yds* | 98 yds* |
|---|---|---|---|---|---|---|
| | | Quarter-Front Below View | | | | |
| B-24 | 100 | 100 | 99 | 100 | 99 | 98 |
| B-17 | 97 | 100 | 96 | 99 | 94 | 83 |
| A-20 | 100 | 96 | 97 | 82 | 23 | 32 |
| B-25 | 100 | 99 | 96 | 99 | 44 | 17 |
| P-39 | 87 | 62 | 54 | 51 | 41 | 17 |
| P-40 | 87 | 56 | 55 | 27 | 11 | 3 |
| | | | Head-on View | | | |
| B-24 | 97 | 100 | 97 | 99 | 84 | 68 |
| B-17 | 96 | 95 | 97 | 96 | 84 | 46 |
| A-20 | 91 | 65 | 46 | 44 | 32 | 20 |
| B-25 | 96 | 100 | 97 | 89 | 47 | 28 |
| P-39 | 57 | 43 | 30 | 28 | 25 | 11 |
| P-40 | 27 | 11 | 8 | 5 | 4 | 4 |
| | | | Plan View | | | |
| B-24 | 99 | 100 | 99 | 100 | 97 | 92 |
| B-17 | 97 | 89 | 90 | 85 | 99 | 92 |
| A-20 | 90 | 99 | 92 | 92 | 68 | 13 |
| B-25 | 99 | 100 | 83 | 68 | 35 | 13 |
| P-39 | 72 | 58 | 48 | 24 | 13 | 25 |
| P-40 | 56 | 31 | 39 | 24 | 3 | 4 |
| | | | Passing View | | | |
| B-24 | 99 | 98 | 94 | 91 | 72 | 42 |
| B-17 | 100 | 98 | 98 | 99 | 93 | 83 |
| A-20 | 100 | 90 | 73 | 58 | 30 | 30 |
| B-25 | 100 | 91 | 67 | 41 | 13 | 13 |
| P-39 | 99 | 93 | 83 | 66 | 15 | 10 |
| P-40 | 100 | 98 | 81 | 52 | 19 | 10 |

*Equivalent distances in miles are as follows: 12 yds, 1/2 mi; 24 yds, 1 mi; 36 yds, 1-1/2 mi; 49 yds, 2 mi; 73 yds, 3 mi; 98 yds, 4 mi.

6. Forecasting the Future of Aircraft Recognition Training

There are many influences affecting the accuracy of aircraft recognition as it was practiced during the last war. A review of influencing perceptual factors, such as visual acuity, adaptation for night vision, angle of regard and eye movements, will be found in Section VIII, "How to See" of "Lectures on Men and Machines" (7). Chapter IX, "Perception and Judgment of Aerial Space and Distance as Potential Factors in Pilot Selection and Training," Army Air Forces, Aviation Psychology Program Research Reports (21) discusses what is known of space perception in relation to the problems of aviation. Section VIII of this report summarized research results on visual perception.

Aircraft recognition was successfully performed during the last war, even though there was much room for improvement. If another war were to be fought with the same types of aircraft, we could consider ourselves as prepared -- assuming a continuation of wartime research on visual perception and procedures for aircraft recognition training. But by the end of the last war it was already evident that existing methods for recognition were being outdated by new forms of aggression through the air, and that the "time" of adequate defense was shortening.

No one can, at present, predict precisely the type of aircraft or airborne projectiles for which spotting or recognition may be necessary in a future war. But it is more than evident to any thoughtful observer that present methods will not do, although they and the research upon them may be useful for other purposes.

As higher and higher speeds of airplanes are achieved, the observer cannot afford the five or ten seconds that it takes for recognition. In that time the aircraft will have traveled several miles. Military aircraft have already been flown at speeds approaching 1000 miles per hour, which is more than a quarter of a mile a second, or the time that it requires to "take a look" -- if you know where to look. To complicate the picture further, many looks in as many "right" places may be necessary to recognize all of the enemy aircraft. The Kamikaze planes came in from 10 or 15 directions. The future may double or triple the number of correct recognitions necessary to be made in a second. But what of spotting of projectiles? What of the time necessary for plotting and communications? A Buck Rogers approach to the problem for the future would seem more nearly adequate than the aircraft recognition training of the present.

Training in aircraft recognition as discussed in this section is outdated. Perception of airborne targets must be a greater distance than is now possible through direct perception, and at greater speed, and necessarily with greater accuracy because

of their increased deadliness. This will be true whether or not the recognition is from ground or air.

What this aircraft recognition may be and what the training for it should be has not been decided. It may, for example, be recognition through some form of radar. Whatever it is, man will have to be trained in indirect recognition via the use of machines. And we can be sure that the procedure and the training for it will be more complicated than in the last war.

J. SPEECH-HEARING PERCEPTUAL TRAINING

The ears are the instruments of perception and understanding in various forms of communication. Such communication is particularly important in warfare where the eyes cannot see—in the dark, around corners, and where distance is too great for any form of visual perception.

Communications via hearing can be divided into systems that use speech and systems of signals for hearing. Transmission may be via air, electrical or electronic systems. Sonar, radio range, and flybar are devices to improve on voice communication by the use of signals.

Communications in all of these systems depend on hearing, or auditory perception, and understanding, for which training must be provided. Systems of voice communication require training in speech.

1. Communications Training

It has been estimated that there are more than 30 variables affecting intelligibility in a simple radio voice transmission system of communications, which include those of the voice of the announcer, of the physical system, and those of the listener. Training is concerned with all such variables including speech, hearing, and the use and adjustment of any device for transmission.

a. Communications Courses.

Training in speech-hearing communications during World War II was usually provided in a two-to-four hour course. Emphasis was on use of the voice; listening training was seldom included. Instruction included suggestions as to loudness, articulation and pronunciation, rate of speech, and pitch of voice. In the American Air Forces, emphasis was usually upon loudness and pronunciation. In the British and Canadian Air Forces it was upon pitching the voice high. Training courses in the American Air Forces usually added high level noise to simulate operational conditions. Practice was given in situations where loud speech and clear pronunciation were necessary. Checks were made for the speaker to judge the adequacy of his performance. It is interesting that all such instruction showed communication intelligibility gains wherever measured.

Present communications courses in the Navy usually involve all forms of communications, including systems based on visual perception. Considerable emphasis is placed on speech intelligibility because of the importance of speech communications within an operational

unit. Particular attention is given in the speech intelligibility training course of Pre-Flight, NATC, to rate of speaking (advised rates of about 2 words per second), to phrasing of speech (advised phrasings of 2 to 6 words), to loudness and pitch (advised that they be maintained constant), and to articulation (advised that distinctness of articulation be over-emphasized). Mirrorphone recordings are made of the student's voice for his study in relation to criticism given him. Demonstration and use of radio equipment is usually included in such courses.

b. Training Manual for Device 8-1.

A training manual has recently been issued in tentative form for the Portable Interphone Trainer, Device 8-1 of the Navy for use by voice communications instructors (13). Training Device 8-1 includes in a single unit the principal equipment for a course in speech training. It has been found difficult to assemble operational equipment for communications training, and this device provides a realistic communications situation.

The manual includes: (a) basic information for the instructor about voice communication; (b) specific operating instructions for the recommended communications training and testing devices; (c) a training program, with minimum optional stages which have been demonstrated to achieve desired results; and (d) recommended testing materials to assess the effects of the training.

2. Research

The early war-time courses in speech intelligibility were based largely upon "know-how" of civilian speech training. During and since the war, extensive research has been carried on in this country and abroad upon both the physical systems and the human factors in speech-hearing communications. Whereas an enormous amount of research has been reported upon speech intelligibility, little is reported upon the actual functioning of auditory perception, which is so important not only in voice communication but in all systems of signal communication.

Numerous studies of the problems of voice-hearing communications will be found in the reports of the Office of Scientific Research and the Special Devices Center, ONR. A final report has been issued summarizing the war-time research of the Office of Scientific Research and Development (3). The "Training Manual for the Portable Interphone

Trainer, Device 8-1" includes a brief summary of research on "intelligibility" in voice communication (13, 20-25). Chapter VI, "Speech, Communication and Hearing" in "Lectures on Men and Machines" (7, 122-145) discusses the factors influencing speech intelligibility, both physical and psychological. Chapter VII, "Special Auditory Informational Systems" of this same publication (7, 146-172) reviews the research on intelligibility of systems of signals.

3. Intelligibility Research

Extensive research has been performed upon the intelligibility of voice communication, and the agreement with respect to the preferred use of the voice is significant.

a. Loudness.

Loudness as a factor in speech communication was recognized as highly important during World War II because of the high noise level in most voice communication systems. Loudness is usually referred to as the most important voice characteristic in its effect upon intelligibility of communications. Research shows that training in loudness of speech, without regard to other vocal factors, will greatly improve intelligibility of speech and that changes in loudness can be readily accomplished through training. But it is necessary that such training emphasize a constant level of loudness. As variability in intensity increases, word intelligibility decreases.

In one study in the Army Air Forces of the relation between voice loudness and intelligibility (39), intelligibility was found to increase progressively through three of four levels of loudness, but either did not rise significantly or decrease when the speaker shouted his loudest. This study was made with hand-held and throat microphones operated in the presence of noise. Another study (40) compared intelligibility of individual speakers at four loudness levels. The relative intelligibility of speakers did not change when speaking at different loudnesses. But the mean intelligibility of the group rose as loudness increased. The increased intelligibility was related to the noise in the communications system. The higher loudness levels of speech showed greater intelligibility when they were necessary to produce favorable signal-to-noise ratios. Where noise pickup was less intense, there was little or no gain in intelligibility with an increased loudness level.

The effect of the loudness of the speaker's voice upon the loudness of the listener's response has been studied in a recent series of experiments in the Navy (4). The data show that the listener responds with greater intensity as he hears more intense signals, whether he is repeating back or answering questions. Also, where the words spoken vary in loudness, the listener is unable to maintain a constant intensity when repeating back. Messages spoken by males and females elicited different intensities, the female being responded to louder. Whereas these experiments were conducted with communications over electrical equipment, similar results would be expected in face-to-face communications.

b. Rate.

Rate of speech was assumed during the last war to be closely related to intelligibility of voice communications, and a slow rate was often advised in voice communications training. Several investigations of rate of voice communication in the Army Air Forces (3) were inconclusive as to the influence of rate on intelligibility, but suggested that rate was not generally the critical element in intelligibility that it had been considered.

The normal range of speech is from 120 to 160 words per minute. Within these limits the rate of utterance is not a critical element in intelligibility of communications. It seems probable that the advantages of slow speaking in voice communications training have been overstressed, although it must be kept in mind that a faster than normal rate is likely to reduce the intelligibility of the message. A speaker's rate is influenced by the rate of the utterances he hears (29). Rapid rates are responded to with rapid rates, and slower rates with slower rates. It seems desirable that abnormal rates be corrected in communications training.

c. Pitch.

Pilots during the last war frequently referred to voices with high pitch as being more intelligible than others. British and Canadian Air Forces training programs included advice to pitch the voice up. Research during the war and since, however, has indicated definitely that pitch is not a factor in intelligibility, provided the speaker speaks at his normal level. Individuals with a normal pitch range should not be instructed to change their pitch. Pitch normally rises with loudness, but this change does not affect intelligibility.

Experiments conducted in the Army Air Forces during the war (31), with student pilots as subjects, found no relation between pitch of voice and intelligibility of communications either among persons with "normal" pitches or among persons trained to use a pitch higher or lower than normal for them. Although students could readily be trained to speak at various pitches, it was found that no significant advantages in intelligibility of communications resulted from such training.

Research has demonstrated that pitch is an unimportant consideration in communications training as long as abnormal pitching of the voice is not adopted by the trainee. A rise in pitch will accompany increases in loudness to accomodate to loud noise. Any instruction to attain adequate loudness is undesirable training procedure.

d. Articulation.

Intelligibility of voice communication is definitely improved through training in articulation or enunciation of words and phrases. Experiments in the Army Air Forces during the last war (32) indicated that one hour of training to pronounce accurately and clearly produced increased intelligibility in voice communications. The type of instructions follows: (a) Instructions to stress final consonants; (b) Instructions to stress sibilant sounds (s, z, sh, zh, ch, j). Demonstrations and practice, both in quiet and noise, were included on precise articulation of words. The gain in intelligibility was particularly marked under noise conditions of voice communication.

4. Suggestions for Training

Experimentation on methods of instruction (3) indicates the advisability of: (a) extensive use of noise in training; (b) teaching voice and messages concurrently with divided emphasis; (c) using demonstration recordings; (d) using objective measures, preferably meters, for loudness criticism, and using such training phrases as "talk louder" or "talk just short of shouting or strain"; (e) using timed sentences for rate drill; (f) saying back words for articulation drill.

Four hours of instruction is recommended for such a course, which would be organized as follows:

Hour I . . . . Intelligibility test; demonstration recording of loudness; loudness drill.

Hour II. . . Continued drill of loudness; demonstration recording of rate; rate drill.

Hour III . . Demonstration recording of articulation; articulation drill.

Hour IV. . . Demonstration on recording of accustomed patterns of speaking; drill procedure review; intelligibility test.

Intelligibility improves very little with operational experience in using interphone and radio equipment. Explanations of voice skill or reading about the use of the voice have little value of themselves as training devices. On the other hand, improvement in intelligibility is characteristic of all voice communication training of the last war. Individual differences between students in intelligibility of voice communication are reduced by training. Indications are that this acquired skill is retained at least over a period of three months.

K. KINESTHETIC (MOTOR) TRAINING

Several problems of perception were evident in the 1948 survey of training in the Naval Air Training Command (37). These were related to the manner in which the student received instruction on the ground. It was pointed out that the method of demonstration on the ground of distances, angles, and "feels" as they seem while in flight, varied from instructor to instructor and had no basis in comprehension by the student unless he had had common experience with the instructor. It was also noted that part of this problem was visual and part kinesthetic perception. Training in kinesthetic motor experience has been subjected to very little research. But what has been accomplished implies that there is much to understand as a basis for good instruction in this area.

1. Muscle Training.

Research was undertaken by the Committee on Selection and Training of Aircraft Pilots upon the effects of muscle potential, muscle tension, and muscle set in pilot performance (19, 27, 28, 30). This research was of an exploratory kind and the information gained from it is useful primarily in indicating the problems of method in the study of muscle activity during flying.

a. Preparatory Muscle Set.

It seems reasonable to expect, from one of these researches (19) that the pre-work or preparatory muscle set, which reflects with considerable exactness the subsequent set of the muscles during work, could serve as a base for motor training in simulated flying or simulated operations of flying instruments on the ground. In this manner, the set of the various muscles for any operation could be corrected before their reaction in performance of the operation takes place. This procedure, however, presupposes either apparatus measuring the tension of specific muscles in preparation for reaction, or specific perception of these muscle sets by the student. As the researches of the Committee on Selection and Training of Aircraft Pilots indicate, the apparatus for measurement of muscle activity is extremely complicated, and the possibility of developing apparatus for application under usual training conditions seems unlikely at the present time.

b. Kinesthetic Perception.

The accuracy of the pilot's perception of his own tension has been questioned; as has the usefulness of instruction by an instructor of kinesthetic "feel". A trial of this procedure (19) indicated that the instruction to "relax" or "tense" a muscle has little value, but that touching a muscle was superior to naming it. It was suggested that where particular muscles could be distinguished as necessary or unnecessary for a performance, orientation before training in their use might be successful in correcting some of the errors of muscular sets in pilot training.

2. Muscle Fatigue.

The Applied Psychology Unit, Cambridge, England, has carried on various experiments upon muscular fatigue effects in aviation training.

a. Maintaining Form.

One of the Cambridge experiments (12) was concerned with training in reducing errors in operating blind-flying instruments under simulated flying conditions in the Cambridge Spitfire Cockpit. The experimental group received instruction as to the nature of the errors. Information was given this group about what conditions would make the subjects liable to the effects of fatigue. No information of this kind was given the control group.

The experimental group made fewer errors than the control group. This was attributed to the group's maintenance of form as a means of resisting the effects of fatigue. Thus it was suggested that maintaining style or form in the operation (as in performing athletic tasks) is a means of reducing pilot errors.

b. After-Contractions in Muscular Fatigue.

Bartlett, of England, calls attention to the after-contraction of muscles as having some positive relation to the efficiency with which a skill involving successive muscular contractions is carried out (1). He refers to experiments carried out by Honeyman of the Applied Psychology Unit, England, showing a significant relation between excess and deficiency of after-contractions and the efficiency of learning new muscular coordinations; also to the onset of fatigue and liability to accidents. He refers to experiments by Hicks of the Applied Psychology Unit, which have shown that the after-contractions are non-voluntary; they are at a maximum when the operator is distracted. When the first contraction is not a return to rest, the effect of the after-contractions from this first contraction are superimposed upon the direction and extent of the second contraction, thus affecting the character of continuous exercise of learning.

3. Present Indications.

As stated earlier, research upon muscle training has not reached the stage of application. There are only hints as to what might be done in instruction; and hints upon what should not be done. Certainly, from present indications, "bright ideas" on motor instruction from those unoriented into research findings in the field should be carefully controlled so that pilot trainées may not be further confused by their instructors.

L. AUDIO-VISUAL AIDS (Special Devices)

It has been characteristic in all training programs in industry, education, and the Armed Forces, to determine the value of training aids by what has come to be called "face validity". By face validity is meant practical opinion of the relation of the aid to progress in training.

The students and instructors must like any device used in training, and training officers must believe the device is worthwhile, for it to be used as an adjunct to training. Such a situation is conducive to progress in training. Students usually progress under any training and no known training device has ever been associated with regression in skills during the training. Operational criteria of progress in training during the period of use of a training device are exceedingly difficult to establish. Thus face validity is usually considered sufficient to determine whether or not a training aid is to be used or continued in a program of training. And face validity usually determines the "aid" as valuable.

Many training aids, such as blackboards, textbooks, amplifying equipment, charts, and models have traditionally fulfilled the requirements of face validity and no one now questions their value in training. Their use is widespread. But the conditions of use of these familiar aids also goes without question, such as the size of lettering on charts for a particular sized class, the position of the blackboard and its lighting, the size of a model in relation to class size. These conditions determine greater or lesser efficacy of the aid in training.

1. Experimental Methods.

Two experimental methods have been evolved to determine the validity of training aids. Both use the parallel group technique. The first compares two face-valid aids to see which produces the greatest achievement at the conclusion of the training, for purposes of selection of a training aid for the training program. The second does not attempt to answer the question of which training aid among those available is better. It tries to answer the question of whether or not a new training device improves training under present conditions. It uses the training situations as a control and compares the results in achievement when the new training aid is introduced into it. If there is improvement, then the training aid is adopted as a feature of the training program.

2. Familiar Aids.

The assumption is frequently made by instructors that what they understand can be understood by the student; that charts, maps, designs, and other training aids are comprehended by the student without training in the use of the training aid.

a. <u>Level of Comprehension</u>.

A graph showing curves of changes with time for various production and personnel indices in an airplane industry was shown to a sample of personnel men with the question, "What does this mean to you?" (22). All curves were of indices with which it was generally expected that personnel men were familiar. But there was little indication that these personnel men related the production and personnel indices in their thinking or interpreted from the production indices needs for employment or of training of personnel.

This illustrates a common situation in much advance instruction, judging from the experience of instructors in colleges and in the training commands of the Armed Forces. In the first place, before using a training aid for training purposes, training is needed in the operations or symbols of the training aids.

b. <u>Learning from Graphic Material</u>.

Added evidence of this comes from a series of experiments carried out by the Applied Psychology Research Unit, Cambridge, England (54), to discover what could be gained from graphs, charts, and tables by persons who have not had wide general education (airmen, soldiers, and training college students, totaling 231). Two sets of data, one dealing with vital statistics and population problems, and the other dealing with statistics relating to the war effort in the United Kingdom were presented in graphs, pictorial charts, and tables or figures, preceded by a short explanatory statement about the information they were to convey. Tests given immediately after study were of two kinds, reports made in own words and answers to questions.

Less than 10% of the attempts made at general statements (reports made in own words) were adequate. The reports "in own words" consisted of isolated facts or irrelevant, incorrect generalizations. In response to specific questions (recall of facts and figures), answers were no more efficient than with the other material, although the more intelligent or better educated were superior. There was no difference between graphs, charts, and tables with respect to the correctness of the factual information derived from them.

It was interpreted from this experiment that the lack of ability to understand the general implications of the data of the experiment was not due to lack of interest, but to the absence of general background of knowledge with which the information could be coordinated. Also, it was evident that training in the use of graphs, charts,

and tables was necessary to their use in instruction. Thus, prerequisite knowledge or training in the way things are presented, the technique of presentation, appeared to be necessary. Such a conclusion applies not only to blackboard, charts, or lantern-slide presentations, but even more broadly to textbook aids of instruction.

3. Special Devices.

Of the hundreds of complicated special devices developed and used in the training of military personnel during the last war, few have ever been validated as contributing to the required training. Those familiar with the problems of transfer regard this as a serious situation, for even those training devices from which training is most obviously transferable are found to contribute very little to the desired training.

a. Evaluation Rationale.

A rationale for the evaluation of special training devices and procedures has been worked out in the Army Air Forces with special reference to evaluations and comparisons for flexible gunnery trainers (24, 255-256), as follows:

1) Training must have validity. Practice in training must improve skill in the task for which training is given. The value of a trainer in doing this job may be estimated in accordance with the following principles:

   a) Training should transfer to some measurable criterion of the skill which is the goal of the training.

   b) Learning must occur in training in order that transfer to a criterion be realized.

   c) Training should have realism—it should resemble the skill which is the goal of training. In general, the closer the resemblance, the greater will be the validity of training.

2) Training should have efficiency. Practice in training should produce measurable results and should do so with a minimum expenditure of time and effort. In order for training to be efficient, the following conditions should obtain:

   a) Training should yield reliable scores representing students' performance; such scores should not be influenced by weather, power supply, or other conditions aside from the ability of the student.

b) Practice should yield analytical scores, revealing the ability of the student to perform the component parts of the training task. Component scores are necessary for effective coaching.

c) Training should provide for the fixation of successful practice by way of immediate and constant knowledge of the correctness of practice.

3) Training should be administratively practical. In order for training to be administratively practical, the follwoing conditions must obtain:

a) Training should be economical. It should not require an excessive amount of instructor or supervisory personnel and the mechanical devices used should not require an undue amount of maintenance and repair, costly in time and manpower.

b) Training should be adaptable to the changing requirements or conditions of training. Installations should not be so constructed as to cause undue delay or re-design in order to keep up with changes in the goal of training.

b. <u>Flexible Gunnery Training Devices</u>.

The Army Air Forces have evaluated their special methods and devices used in flexible gunnery training from 1942 to the end of the war according to this rationale (24, 141-258). Descriptions of the devices and data on reliability, learning realized, and the degree of transfer to selected operational criteria are given in Table 1. These devices are listed according to eight characteristics considered for effective training, as follows:

1) <u>Transfer</u>

* . . . . . . . . . . . . . .No evidence.
Slight . . . . . . . . . . . .Some favorable evidence.
Doubtful . . . . . . . . . . .Negative results in study.

2) <u>Learning</u>

* . . . . . . . . . . . . . .No evidence.
Doubtful . . . . . . . . . . .Scores unreliable and gains slight.
Probable . . . . . . . . . . .Inferred from transfer to criterion.
Slight . . . . . . . . . . . .Some change in proficiency observed.
Moderate . . . . . . . . . . .Considerable change in proficiency over several trials.
Marked . . . . . . . . . . . .Marked change in proficiency, continued over large number of trials.

3) <u>Realism</u>

| | |
|---|---|
| Slight | Resemblance only to limited aspects of goal of the trainer. |
| Doubtful . . . . . . . . . . | .Some resemblance to the gunner's combat job, but with important differences. |
| Moderate . . . . . . . . . . | .Fair resemblance to important aspects of the gunner's combat job, without important differences. |
| Marked . . . . . . . . . . . | .Close resemblance to gunner's combat job. |

4) <u>Reliability of scores under usual operating conditions</u>

| | |
|---|---|
| * . . . . . . . . . . . . . | .Unknown. |
| Low . . . . . . . . . . . . | .Most coefficients below 0.60. |
| Moderate . . . . . . . . . . | .Most coefficients between 0.60 and 0.80. |
| Satisfactory . . . . . . . . | .Most coefficients above 0.80. |

5) <u>Information regarding errors</u>

| | |
|---|---|
| No . . . . . . . . . . . . . | .The score or record of performance does not tell nature of errors in performance. |
| Yes . . . . . . . . . . . . | .Score or record provides information on nature of errors. |

6) <u>Reinforcement of success</u>

| | |
|---|---|
| No . . . . . . . . . . . . . | .Knowledge of effectiveness of practice not given student constantly during, or immediately following (less than 1 second), practice. |
| Yes . . . . . . . . . . . . | .Student can tell at all times how effective is his practice. |

7) <u>Economy</u>

| | |
|---|---|
| Poor . . . . . . . . . . . | .Extremely expensive. |
| Fair . . . . . . . . . . . | .Very expensive, but less so than trainers rated poor. |
| Good . . . . . . . . . . . | .Expensive, but less so than trainers rated fair. |
| Excellent . . . . . . . . . | .Relatively inexpensive. |

8) Adaptability

Fair . . . . . . . . . . . . Rigid and resistant to adaptation without great effort on the part of many people.

Good . . . . . . . . . . . . Adaptable with only moderate difficulty.

Excellent . . . . . . . . . . Adaptable with little or no trouble.

* No rating was appropriate or no data were available on which a rating could be based.

c. A Special Device for Navigation Training.

The Army Air Forces have checked the validity of their G-2 Dead Reckoning Trainer for Navigation training by comparing training with this device and navigation training of the classroom (18, 174). The Dead Reckoning Trainer consisted of 48 individual booths, each containing the following instruments for navigation estimation: air-speed meter, compass, altimeter, temperature gauge, clock, and drift meter, and a master control unit for setting the problem. The device had, as can be understood, high face validity. The classroom training used data printed on the blackboard or on a large mock-up, instead of being read from the instrument dials as when the training device was used. An equal amount of time was spent by parallel groups in each type of training.

There was no consistent difference in the final accomplishment from training with the Dead Reckoning Training and the training of the classroom as described above. Simple blackboard presentations or mock-ups for navigation training were not significantly inferior to training with the expensive special device. Such a comparison might indicate similar results for many training devices with recognized face validity.

4. Training on the Trainer.

The first validity check to be made of any training device is to determine if it trains and the extent to which it trains. That is to say, has the trainer, itself, sufficient variability to be used in the development of the skill for which it trains. This is a question that must be answered before validity is determined upon transfer to the requisite training.

A substantial amount of research of this kind was performed in the Air Forces upon Flexible Gunnery Trainers (24). It is sufficient to illustrate this kind of validity check with

Table 1

SUMMARY EVALUATION OF FLEXIBLE GUNNERY TRAINING DEVICES AND PROCEDURES

| Training Device or Procedure | Validity | | | Training Effectiveness | | | Practicality | |
|---|---|---|---|---|---|---|---|---|
| | Transfer | Learning | Realism | Reliable Scores | Error Information | Success Reinforcement | Economy | Adaptability |
| Reflectone trainer | * | Slight | Slight | Satisfactory | Yes | Yes | Good | Excellent |
| Full scale range estimation | * | * | Moderate | Low | Yes | No | Fair | Excellent |
| RCAF range estimation training | * | Marked | Slight | * | Yes | No | Excellent | Good |
| Radar AN/APG-15 T1 | * | Moderate | Marked | Satisfactory | Yes | Yes | Fair | Good |
| B-29 Manipulation trainer | * | Moderate | Moderate | * | Yes | No | Fair | Excellent |
| E-8 spotlight, fixed sight | * | Marked | Slight | Low | No | Yes | Good | Fair |
| E-8 spotlight, comput. sight | Slight | Probable | Moderate | Doubtful | No | Yes | Good | Fair |
| E-14 trainer | * | * | Moderate | Moderate | Yes | Yes | Excellent | Good |
| Waller trainer | * | Marked | Moderate | Moderate | No | Yes | Fair | Fair |
| DeVry panoramic trainer | Doubtful | Marked | Moderate | * | No | Yes | Good | Good |
| AAFSAT B-29 trainer | * | Moderate | Moderate | Moderate | Yes | Yes | Excellent | Good |
| Aircraft recognition | * | Marked | Moderate | * | Yes | No | Excellent | Excellent |
| Skeet shooting | * | Slight | Doubtful | Satisfactory | No | Yes | Excellent | Fair |
| Basic deflection | Doubtful | Moderate | Doubtful | Satisfactory | No | Yes | Excellent | Fair |
| High tower | * | Moderate | Doubtful | Moderate | No | Yes | Good | Fair |
| Moving base | Doubtful | Moderate | Doubtful | Satisfactory | No | Yes | Good | Fair |
| Giant skeet | * | Marked | Doubtful | Moderate | No | Yes | Excellent | Fair |
| Moving target, hand-held guns | * | * | Slight | Moderate | Yes | No | Good | Fair |
| Moving target, turret guns | * | * | Moderate | Low | Yes | No | Fair | Fair |
| Burst control range | * | Moderate | Slight | Satisfactory | Yes | No | Good | Good |
| Poorman range, fixed sight | * | Marked | Marked | Moderate | Yes | No | Fair | Good |
| Poorman range, K-13 sight | * | Marked | Marked | * | Yes | No | Fair | Good |
| OQ-3 radio controlled target | * | * | Moderate | * | No | Yes | Fair | Excellent |
| Air firing | * | Doubtful | Moderate | Low | Yes | No | Poor | Poor |
| Gun camera | * | Moderate | Marked | Moderate | Yes | No | Poor | Excellent |
| Frangible bullet | * | Slight | Marked | Low | No | Yes | Poor | Fair |
| Firing error indicator | * | Marked | Marked | Low | Yes | Yes | Poor | Fair |

reference to the Reflectone Trainer used in range finding in ground flexible gunnery training. It was found that, under conditions of the classroom, gunners learned little after about 150 settings of the apparatus and that most of the learning in estimating range on this trainer occurred during the first 30 settings. On the basis of these results, it was estimated--assuming that this training transferred to the air situation--that several hours of the simulated training could be dispensed with.

## M. AIR VALIDATION (TRANSFER OF TRAINING FROM GROUND TO AIR)

Much is said elsewhere in this report about the transfer of training from ground to air which is, of course, the purpose of ground training in aviation. Research aims to answer the question of what is transferable, for what can be transferred is exceedingly important in reducing the costs of materials, time, and often loss of human life.

### 1. Point of View.

It has seemed to many investigators that the learning of a complex skill, such as that used in operating an airplane, is to a large extent determined by the complexity of the stimulus situations to which the subject must react, rather than to the demands made on the trainee's specific learned abilities. This may explain why a skill learned on the ground, such as sighting a gun on a target, appears to contribute so little to gunnery efficiency in the air.

Because of this, it is frequently said that the learning of motor tasks is largly a matter of learning perceptual relationships, that the "perceptual aspect" of the task is the one thing which has the greatest effect on the learning of the total skill. The results of aptitude testing in the Armed Forces provide considerable evidence for this point of view. These results indicate that the task of learning to fly is an ability which receives heavy contributions from a variety of perceptual abilities.

The skill of responding correctly to the actual situation, such as attaining firing position in air combat, can only be acquired through practice in the situation. But what contributes to the development of this skill is another matter.

Here is where ground training comes in with its contribution of aids both to perceptual learning and to the coordination of motor with perceptual skills such as knowledge of aerology, engines, and the behavior of people; and of skills in reading dials, moving levers, and communications. All that is learned on the ground should be prerequisite to the training in the air where the real learning situation exists.

This brings us to the problem of determining what training on the ground does contribute to the ability to fly an airplane. Does theoretical subject matter, such as knowledge of aerology or interpretation of human behavior, contribute to it? These are the academic subject matters of the ground curriculum. Does training in the use of operating equipment, such as guns, engines, radio, and radar, contribute to it? These are subjects concerned with equipment. Does training in situational skills, simulated air situations, such as training in the Link trainer or any trainer that endeavors to simulate the aid situation, contribute to the ability to fly an airplane?

Unfortunately, there are very few answers to these questions beyond those offered by face validity. Of course, a pilot must be skilled in navigation if he is going to find his way back to the carrier. He must know how to read various instruments if he is going to fly blind Such ground training appears necessary, even though its contribution to skill in the aid cannot be demonstrated.

The question is not so much one of whether ground training as it is today contributes to learning in the flying situation. It is more a question of, first, what training contributes to the flying situation, and second, how much does it contribute.

Little indicateion here and there in answer to these questions are often startling: A simulated trainer of marvelous design and produced at tremendous cost does not reduce the air training time. Results from the use of several trainers designed to effect the training do not correlate. A course in training on equipment does not add to efficiency in operational units; shorter courses in practice on simulated equipment place students at the same level in operational training units as do longer courses. Thus, the question of what can be taught to advantage on the ground in aviation training is today just as puzzling as it was in 1940.

These questions must be answered from the point of view that what is learned on the ground is prerequisite to, or background for, learning that must be accomplished in the air.

2. Perceptual Training.

An attempt has been made to discover to what extent motor learning could be facilitated by different amounts of practice on the pictured task (20) as a way of contributing to the solution of the problem of transfer of motor skills from ground to air.

A paper-and-pencil representation of a motor task was practiced a different number of times by four experimental groups of 30 Navy enlisted men and a comparable fifth group, which had no such practice, served as a control. The motor skills consisted of four different manual responses to four panel lights, differing in color and position. The four experimental groups practiced the paper-and-pencil representation of the motor task 8, 16, 24, and 48 trials respectively. Following this simulated practice, the four experimental groups and the control group practices the motor task for 60 trials. The learning was measured in terms of time required for each correct reaction and number of errors.

The effect of simulated practice came late in the motor learning. There was no significant difference for the different groups on the first 10 trials of practice on the motor task. But by the 30th practice in the motor learning, the response time had decreased proportionately to the number of trials of simulated practice. There was, however, a progressive reduction in total number of errors from the beginning of motor practice proportional to the number of trials of simulated practice. The point of maximum errors shifted progressively nearer the beginning of the learning of the motor task according to the amount of simulated practice. In the control group and the group having 8 trials, the point of maximum errors was passed after the 40th practice. In the groups having 16 and 24 trials, this point was passed by the 20th practice. In the group having 48 trials, the point of maximum errors was passed by the 10th practice.

The results indicate considerable effectiveness of this type of simulated training where perceptual elements and not motor skills are practiced for transfer to the operational training. In this instance, 16 trials of simulated practice and 30 practices of the motor task accomplished 80 percent of the total learning, whereas 30 practices of the motor task alone brought only 40 percent of the total learning. Attention is called, particularly, to the fact that the training aid used showed no transfer to the initial performance of the training task, regardless of how much simulated training took place. This finding should instill a habit of caution in estimating the validity of all simulated training devices, and particularly those which aim to orient or establish attitudes for later specific learning.

3. <u>Transfer of Training From Ground School Courses.</u>

Instances are reported where ground and flight proficiency in aviation training are fairly closely related. This may be due to the fact that students who are superior in one form of training are more likely to be superior in other forms of training. It also may have implications that the ground training contributes to the flight training.

a. <u>Navigation Training.</u>

Correlations supporting this latter contention are reported from the Army Air Forces (18, 122) between ground school grades and the flight final average for 308 graduates in Navigation training as follows:

Flight average grades vs Lecture final average . . . .46
Flight average grades vs. Exam. final average . . . . .49

The reliabilities were as follows:

| | | |
|---|---|---|
| Lecture grades | . . . . . . . . . | .82 |
| Examination grades | . . . . . . . | .90 |
| Flight missions | . . . . . . . . | .72 |

The correlation between lecture grades and the examination grades was .78.

b. Fixed Gunnery.

A comparison of the effect of a ground gunnery course upon air skill in fixed gunnery was made in the Army Air Forces (18, 175-176). Students who had completed the basic gunnery course of 6 weeks were compared upon efficiency in gun camera missions with students who had no such training. After the fifth gun camera mission, the two groups showed no difference. In other words, the training received in the 6-week basic gunnery course was balanced by 3 or 4 minutes of actual turret operations in the air. This result is explained by the fact that the ground training did not include the essential elements of the air firing situations which were not mere sighting of a gun on a target.

c. Flexible Gunnery.

A comparison was made by the Army Air Forces (18, 175-176; 24, 224-237) of a 2-weeks intensive ground course for 16 Sperry gunners on the Sperry Spotlight Trainer, and for 16 Martin gunners on the DeVry Panoramic Trainer. Initial proficiency scores and final proficiency scores were established by 3 gun-camera missions. Training on the Sperry Trainer decreased tracking errors, but framing errors remained the same. Training on the Panoramic Trainer did not significantly improve the Martin gunners. Thus, this form of specialized training on the ground was ineffectual, evidently here as in the basic gunnery course because the air situation was quite different from that of the training course.

4. Transfer from Special Devices.

A few ground training devices have been validated upon their transfer of training to operations in the air, as has been indicated above. A careful trial was made in the Army Air Forces (18, 174-175; 33, 285-287) of a self-reflecting optical sight attached to a conventional shotgun for practice in skeet firing for its transfer effect in teaching the sight picture for air-to-air fixed gunnery. It gave the student firing skeet the same picture seen in later fixed gunnery training when making passes at an aerial towed target. Thus the device had high face validity for transfer from ground to air training.

Two groups of about 150 students in fixed gunnery training were compared as follows:

a. Group I, trained on the ground with the optical sight, obtained an average score of 32.16 in terms of percent hits in later air-to-air fired-gunnery firing.

b. Group II, trained on the ground with the conventional shotgun sight, obtained an average percent hits of 29.97 in air-to-air gunnery.

The difference between the means of the groups, 3.19, gave the group trained with the optical sight an average of 11% more hits in air-to-air gunnery. The critical ratio of this difference was 2.4, indicating that this difference could occur by chance less than one time in 100 such samples. Thus it was concluded that the self-reflecting optical skeet sight was a valuable addition to ground training. How quickly its transfer effect would have been overcome in air-to-air training was not determined, although this is an important question in the use of ground training devices.

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